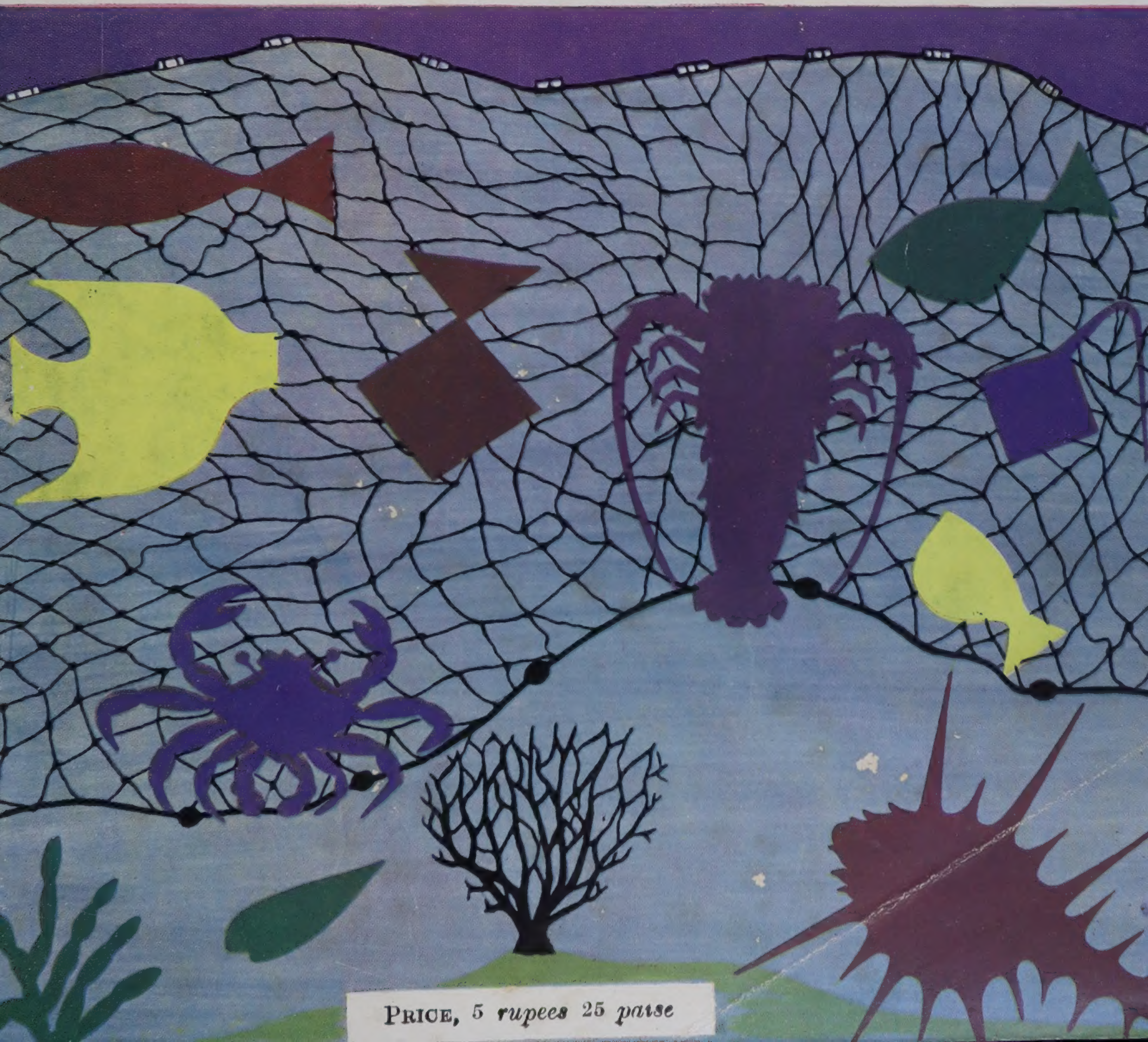
MADRAS JOURNAL OF FISHERIES

GOVERNMENT OF MADRAS

VOLUME-IV **JULY 1967**



PRICE, 5 *rupees* 25 *paise*

MADRAS JOURNAL OF FISHERIES

VOLUME—IV

JULY 1967

CONTENTS

PAGE

1 Trend in the Fisheries of the Adyar Estuary from April 1963 to March 1965 by Thmt. Gemma Evangeline .. 1
2 Salinity and temperature variations over Pearl and Chank Beds of Tuticorin by Thmt. Freda Chandrasekaran, A. D. Isaac Rajendran and C. Malupillay .. 21
3 Observations on the Hydrography and Planktology of Pearl Banks of Gulf of Mannar by Thmt. Freda Chandraseharan and K. Sudhakar .. 28
4 The elements of the adhesive disc of Echeneis and their homologies by B. Bonnell and Thmt. K. Jeyachandran .. 34
5 An unusual mortality of Marine Fauna in the Southern beach of the Krusadai island by K. Sudhakar and S. Antony Doss .. 36
6 A note on the Veliger Larvae in Plankton collected from Thollayiram Par by K. Sudhakar and Thmt. Freda Chandrasekaran .. 38
7 Survey of Fishing grounds in the Inshore waters of Bay of Bengal near Madras in 1965–66 by P. I. Chacko and Mohamed Sultan .. 42
8 Location of Fishing grounds in the inshore area of the coromandel coast of South Arcot district in 1963–66 by P. I. Chacko and M. V. Natarajan .. 46
9 Survey of Fishing grounds in the Palk Bay and Northern sector of the Gulf of Mannar off Rameswaram, Pamban and Mandapam by P. I. Chacko and Abdul Rahim .. 47
10 Economics of operation of motor fishing vessels along the coast of Madras State by P. I. Chacko and S. Thyagarajan .. 56
11 Fish production in two temple tanks in Madurai city and an ecological study thereof by A. Sreenivasan .. 58
12 A note on the effect of some trace elements on primary production and Fish yield in small ponds by A. Sreenivasan and R. Sounder Raj .. 62
13 South Indian Fresh Water Diatoms by T. Franklin .. 63
14 On the Fish curing practices at Cape Comorin by Joseph, K. C. and Srinivasan, R. .. 71
15 Studies on the optimum moisture content of dried white baits (Anchoviella sp.) by Joseph, K. C. and Srinivasan, R. .. 75
16 A note on the use of Sodium Benzoate and Sodium bicarbonate in the preparation of dried salted fish by Joseph, K. C. and Srinivasan, R. .. 89
17 Some studies on the processing and utilization of seaweeds of Madras State by Srinivasan, R. and Santhanaraj, T. .. 92
18 Variations in proximate and mineral composition of the muscle of crocodiles from Bhavanisagar Reservoir by A. Sreenivasan and R. Sunder Raj .. 98
19 A note on the proximate composition of Turtle, Testudo elegans by A. Sreenivasan and Sounder Raj, R. .. 100
20 Clinometer by K. A. Dorai Rajah .. 101
21 An improvised wood working lathe by K. A. Dorai Rajah .. 104

EDITED AND PUBLISHED BY
THE DIRECTOR OF FISHERIES

TREND IN THE FISHERIES OF THE ADYAR ESTUARY FROM APRIL 1963 TO MARCH 1965

BY

THMT. GEMMA EVANGELINE, M.A., ASSISTANT DIRECTOR OF FISHERIES (MARINE BIOLOGY), MADRAS-6.

Introduction.

A study of the hydrobiology and fisheries of the Adyar Estuary was made by Chacko, Srinivasan, George, Krishnamurthi and Ganesan in 1954 for the proper conservation and exploitation of the fishery. In addition to the licensing system introduced in this estuary from 22nd March 1953, they suggested the introduction of the imported exotic cichlid fish Tilapia mossambica to further enrich the fishery. 15,000 Tilapia mossambica were introduced for the first time into the Adyar river below the Saidapet Road Bridge in the middle of December 1957 on the suggestions of Devadoss and Chacko 1953, Chacko and Krishnamurthi 1954 and Chacko, Srinivasan, George, Krishnamurthi and Ganesan 1954. Chacko and Venkataswami 1958 point out for the first time the appearance of Tilapia mossambica in the catches of the Adyar estuary in the same year. It is quite evident from this that the introduction had been quite successful and the survival remarkably good. Later Thmt. J. G. Abraham, 1961 remarks that Tilapia had established itself very well in the backwaters of Adyar river but had not done so in the Cooum river.

Attempts have been made in a period of two years from April 1963 to March 1965 to study the fishery of the Adyar river along with other influencing factors such as physical conditions, chemical conditions of the estuary, soil conditions and planktonic conditions with a view to assess the trend of the fishery and the extent to which the fishery has been enriched or adversely affected by the introduction of Tilapia mossambica.

Materials and methods.

The fishing area of the estuary includes the Adyar Fish Farm and Reservoir and the Adyar estuary along with streams, creeks, and paravals that join it for a distance of five miles from the mouth to the Kundugal madugu at Saidapet which is the brackishwater limit. The catches from this area were examined twice daily at 8 a.m. and 2 p.m. Particulars of nets operated and their respective numbers, fish available, their respective size ranges, percentage composition by weight, total landing of fish and such other data were recorded. Monthly averages were assessed from the daily recordings.

Meteorological conditions of the area were recorded daily. Surface water samples were collected twice in the month two furlongs away from the mouth and were analysed for their chemical contents. Soil samples were collected once a month for chemical analysis in the second year of the study. Plankton samples were collected twice in the month at 6 a.m. and analysed quantitatively and qualitatively. A conical townet of bolting silk 80 cm. in length and 25 cm. in diameter was used for the collection of plankton. The net was hauled for a fixed duration of 10 minutes over a fixed distance. The sediment obtained on centrifuging of the samples was measured and recorded. Organisms present in 1 centimetre of the sediment were counted with the help of a counting chamber.

Observations—(*A*) *Physical Conditions* (See *Tables* 1 *and* 2)—1. *Sand Bar.*—The opening and closing of the bar connecting the Adyar river with the Bay of Bengal was recorded as follows between the April 1962 and March 1965:—

Date of closing.	*Date of opening.*
(1)	(2)
4th May 1963	24th August 1962.
9th January 1964	21st October 1963.
30th January 1965	5th September 1964.

2. *Rainfall.*—Rainfall was recorded in eight months in 1963 but only in five months in 1964. There are two periods when rain can be expected. There are local rains and floods in June-July which is the fag end of the South-West monsoon and there are heavy rains and fresh water floods between October and December when the North-East monsoon comes down in full sway.

3. *Maximum and minimum air temperature.*—Highest air temperatures were recorded between May and July and went up to as high as 31°C. Lowest air temperatures were recorded in December-January and went down to as low as 23°C.

4. *Relative humidity.*—Maximum humidity was recorded in June-July when it reached as much as 94 per cent. Minimum humidity was recorded in May in 1963–64 and in January in 1964–65. The lowest value recorded was 71 per cent.

(*B*) *Chemical conditions* (See *Tables* 3 *and* 4)—1. *Depth.*—Maximum depth recorded was 2·251 metres and minimum depth 1·03 metres. Depth is greatest usually in December and lowest in July.

2. *Turbidity.*—Water was found to be very clear in August-September before the onset of the monsoons and was found to be turbid due to silt carried by freshwater floods in December and due to phytoplanktonic production in May. Highest value was 64·5 cm. and lowest value 38 cm.

3. *Specific gravity.*—Highest values of specific gravity were found in March, April, May and lowest values in October, November when there are heavy rains and floods diluting the estuarine waters. Maximum recorded was 1·028 and minimum 1·004.

4. *Surface temperature.*—Low surface temperatures were recorded in October, November when it was as low as 22°C and high surface temperatures in April-May when it rose up to 32°C.

5. *Salinity.*—April and September were the months when high salinity of as much as 22·84 per thousand was recorded while minimum salinity as low as 3·557 per thousand was recorded in October-November.

6. *Oxygen contents.*—The range of dissolved oxygen contents was recorded between 2·24cc/L and 4·67cc/L. It is low between October and March.

7. pH.—pH range is between 7·8 and 8·6. Low values were recorded round, November, December and high values in April and July, August.

8. *Carbon-dioxide contents.*—Carbon-dioxide was absent in all months except in November, December when it varied between 2·0 p.p.m. and 4·0 p.p.m.

9. *Carbonates.*—This ranged from 2·0 p.p.m. to 4.0.p.p.m. except in November or December when it was nil. It was normally 3·0 p.p.m.

10. *Bicarbonates.*—Bicarbonates ranged from 30·50 p.p.m. to 57·95 p.p.m. Lower values were noticed between October and January.

11. *Silicates.*—The recorded values ranged from 9·0 mgm/L to 39·0 mgm/L. Values were found to be low in July and between November and January. An alternating of high and low values is a special feature of the year 1963–64.

13. *Phosphates.*—This varied from nil to as much as 1·8 p.p.m. 'NIL' and traces were recorded in January, February 1965.

(*C*) *Soil conditions.*—(See *Table* 5.)—The bottom soil of the estuary consists of sand covered over with black alluvial deposits and decaying organic matter. The chemical nature of the surface soil shows high chloride contents of 50 p.p.m. to 150 p.p.m. from December to March and an absence of calcium, sulphates, ammonia, magnesium, iron and aluminium throughout. Phosphorus contents were high in April, May, and nil in November. pH which ranged from 6·0 to above 8·0 was highest in October.

(*D*) *Planktological conditions* (See *Tables* 6, 7, 8, 9 *and* 10)—Table 6 shows the planktonic sediment obtained on the average per haul during the various months of the year for two years This is found to vary from 0·3 cc to 1·05 c.c. High sediment value is observed in August, September before the opening of the bar. It decreases in the month the bar opens and again increases in the next two months. The high value before the opening of the bar is found to be due to planktonic bloom, while the high value after the opening during the monsoon months is partly due to silt carried down by fresh water floods from the upper reaches.

Tables, 7, 8, 9 and 10 show the important phytoplanktonic and zoo planktonic organisms that occur in the estuary in the various months of the year. This has been observed for two years. Two peak periods in the occurrence of phytoplankters are noticed. The first is in April, May, June after the closure of the bar. The second is in November, December, January after the opening of the bar and the regulation of the tides. Increased temperature followed by intense evaporation and a consequent concentration of nutrient salts encourages phytoplanktonic bloom in the first peak period when phytoplanktonic production is at its highest. Zooplankters are found to be more abundant in the monsoon and post monsoon periods. Showers and fresh water floods induce the spawning of Crustaceans Molluscs and Polychaetes and their larvae are abundant in November, December, January. Medusae, Amphipods and Peridinium increase in numbers rapidly between March and June.

(*E*) *Fish and fisheries* (See *Tables* 11 *to* 16).—The common fishes contributing to the fishery of the estuary fal under four categories as follows.—

1. Freshwater forms which enter the estuary during floods which occur regularly during the north-east monsoon between October and November and sometimes during the south-west-monsoon between April and June. They consist mainly of Macrones vittatus and Macrones gulio, Barbus sp Ophiocephalus sp. Palaemon sp. Rhyncobdella aculeata and the like.

2. Introduced varieties which consists mainly o Tilapia mossambica a fresh water form.

3. Marine fishes which enter with the tides consequent on the opening of the bar in September, October and which do not enter once the bar closes between January and May These consist of Sillago sihama, Chanos chanos, Megalops cyprinoides, Elops saurus, sharks, rays, Cynoglossus dispar, marine mullets, Polynemus tetradactylus, Stolephorus, Engraulis purava, Caranx sp. Chaetoesus nasus Arius sp. Serranus sp. Lutjanus sp. Latis calcarifer Penaeus indicus, Penaeus carinatus, Metapenaeus monoceros Metapenaeus dobsoni, Gerres filamentosus, Leiognathus sp. Ambassis commersoni and such others.

4. Fresh water or marine forms permanently domiciled in the estuary. These consist of Gobius sp. Etroplu suratensis, Etroplus maculatus, Mullets, Therapon jarbu Macrones sp. Palaemon sp. and such other which hav left their original habitat and have settled permanantly in the estuary.

While the forms that enter from the sea or upper reaches are seasonal in their occurrence the introduced forms and the permanent domiciles of the estuary are availabl throughout, contributing mainly to the fishery in th absence of the migratory forms.

About 31 genera of fish commonly contributing to th estuarine fishery have been listed in the study made fo two years. Several species have been recorded for mos of the genera. All sizes ranging from 2·5 c.m. to 7·0 c.m are being landed and it is found that while certain specie occur year in and year out certain others occur in certai years only. Thus Teuthis java which was recorded i 1963–64 was totally absent in 1964–65. Anchoviell commersoni recorded in 1962–63 was not found in 1963–6 and 1964–65. While 30 genera have been recorded i

1963–64 only 25 genera have been recorded in 1964–65 of which 6 genera present in the first year were not recorded in the second year and one genus present in the second year was absent in the first year.

Tables 11 and 12 show the landings of Prawns, Fish, Crab and the total landings in the various months of 1963–64 and 1964–65 with the first three predominent varieties of the month in their order of predominence. Tables 13 and 14 show the size and percentage composition of the commonly occurring genera and species during the various months in 1963–64 and 1964–65. Tables 15 and 16 show the commonly used tackle in the estuary which consist of Cast nets, Kondavalai or dragnets, Rod and line, Siruvalai or bag nets, Kannivalai or Gillnets and Poovalai or bottom trawls. The average number of each kind of net used per day in each month of the years 1963–64 and 1964–65 has also been rcorded. Histograms. 1 and 2 show the monthly distribution of the major fisheries of the Adyar estuary consisting of Mullets, Prawns, Sillago sihama, Tilapia mossambica and Cat fish and the other mainly marine but including a few estuarine and freshwater forms that occur in small numbers classed as a whole as " other fish ". Clear differences are noticed in the two years. "Other fish" predominate in both years but is higher in 1963–64. The order of predominance is as follows in the two years :—

1963–64. (1)	1964–65. (2)
I. Other fish	Other fish.
II. Prawns	Tilapia mossambica.
III. Mullets	Cat fish.
IV. Tilapia mossambica	Prawns.
V. Cat fish	Mullets.
VI. Sillago sihama ..	Sillago sihama.

These differences are closely linked with the meteorological and hydrographical differences noticed in the two years.

Pie diagrams 1 and 2 show the annual distribution of the major fisheries of the Adyar estuary for 1963–64 and 1964–65. Vast differences are noticed here again and can be easily explained when a note is made of the prevalent meteorological and hydrographical conditions of the two years which also varies though similar in general principle.

Discussion :

A close study of the physcial and chemcial conditions of the two years clearly show how that in spite of the principle similarities in the two years consequent on the inevitable changing seasons of the year such as—

(*a*) summer period between April and June,

(*b*) pre-monsoon period between July and September,

(*c*) monsoon period between October and December, and

(*d*) post-monsoon period between January and March, there are distinct differences in meteorological factors which alter the hydrographical conditions, the planktonic production, the fish production and finally the catch effort of the fishing population.

Thus rainfall was recorded in eight months in 1963 but only in five months in 1964. As a result the bar closed as late as fourth May in 1963 and as early as ninth January in 1964. and thirtieth January in 1965. When the bar remains open chemical conditions are far different from what it would be were the bar closed. There is free tidal ingress and egress as a result of which the depth of water is far greater, being 22·51 metres in April 1963 and only 18·16 metres in April 1964. Salinity is higher due to entry of sea water being as much as 22·84 parts per thousand in April 1963 and as low as 9·813 in April 1964. Turbidity is as low as 77·001 c.m. in April 1963 and as high as 51·0 c.m. in April 1964. Silicates are as high as 30 mgs./L. in April 1963 and as low as 15 mgm./L in April 1964. Planktonic sediment is as low as 1·65 c.c. in April 1963 and as high as 2·26 c.c. in April 1964. More of marine plankton is found in April 1963 while more of fresh water planktonic forms are found in April 1964. The prawn fishery which is mainly a marine fishery comes first on the list in April 1963 but is negligible in April 1964, the total landings being 1261 kgs. in April 1963 and 268 kgs. in April 1964.

The late closure of the bar in 1963 has had its effects not only on the conditions of the adjoining one or two months but on the conditions and fishery of the whole year (See Piediagrams 1 and 2. " Other fish " consisting mainly of marine species have been as much as 39·59 per cent in 1963–64 when the bar was open till May 1963 and only 35·03 per cent in 1964–65. Prawns landings formed 23·2 per cent of the whole in 1963–64 and were as low as 6·78 per cent in 1964–65. Sillago sihama also a marine fishery was higher in 1963–64 when it formed 4·23 per cent of the whole and formed only 2·67 per cent in 1964–65. Tilapia mossambica formed 25·17 per cent in 1964–65 when the bar closed as early as January 1965 and formed only 9·67 per cent of the whole in 1963–64. Similarly catfish formed 11·33 per cent of the whole in 1964–65 and 8·55 per cent only in 1963–64. Further from Histograms 1 and 2 it will be noticed that Mullets were available in all months in both years as they become part of the permanent estuarine fish fauna. Catches of "Other fish" were at their peak in October in both years soon after the opening of the bar and were high in January, February, March which may be clearly attributed to the free inplay of tides consequent to the opening of the bar. Prawns were available throughout the year when the bar closed in May in 1963 as the fry which entered in May would take at least four months, i.e., September to attain a commercial size by which time the bar opened up again in October 1964. In 1964–65 however prawns were absent after May 1964 as the fry that entered in January 1964 when the bar closed would be fished out completely in four months, i.e., May when they attained marketable size after which fresh stock could enter only in September when the bar opened. Sillago sihama was available throughout the year in 1963–64 due to the free inflow of tides for nine months in the year while it was present in small numbers in April/May 1964 and was absent between June and November 1964 because of the early closure of the bar and was present in the usual normal numbers between December 1964 and March 1965. However it is found that the freshwater species such as Tilapia mossambica and Macrone gulio are more abundant in the year when the closure of the bar was early. Catfish were present in June, July and September in 1963–64 but they were abundant in the same months in 1964–65.

Tilapia was present from May to March in both years 1963–64 and 1964–65 but was abundant between June 1963 and September 1964 and November 1964 and January 1965. It is also interesting to note that the green crab Scylla serrata which was available between June 1963 and October 1963 in 1963–64 was absent throughout in 1964–65 which shows that a tidal environments is necessary for this fishery also. *See* Tables 11 and 12.

It is seen from Tables 15 and 16 that the fishing activity in the estuary is undoubtedly greatly influenced by the abundance of fish. The total landings in 1963–64 amounted to 21·6 metric tonnes while it was only 7·2 metric tonnes in 1964–65. More nets and tackle have been used throughout in 1963–64 than in 1964–65. More fishermen concentrate on fishing in the Adyar estuary when the fishery is good but earn their living by migrating to nearby backwaters and estuaries such as that of Covelong and Ennore when the fishery in the Adyar estuary is poor.

This study of the physical, chemical and biological conditions of the Adyar estuary for two years along with the fish yield makes it clear that fish yield can be increased three fold by keeping the bar open three months longer than the usual month of closing and can be increased several fold if the bar is kept permanently open. The prawn fishery can be harvested throughout as prawn larvae enter as long as the bar is open and are abundant both in the post monsoon and summer periods. Prawns are in much demand in the city and the amount harvested is insufficient to meet the demand. Tampi 1959 has also pointed out the significance of the time of opening of the sand bar and the satisfactory tidal flow from the sea with regard to considering the extended duration of fishing activity and thereby the fish yield in a salt water lagoon near Mandapam, by preventing the formation of sand bars. The same need is felt here also and all efforts have to be taken to retain a permanent connection of the estuary with the sea.

The introduction of Tilapia in December 1957 has been highly successful and they have not only survived but are also breeding in a salinity which varies from 3·557 per cent to 22·42 per cent. This is more significant in that similar attempts in the Cooum river have been unsuccessful as recorded by Abraham 1961. Tilapia have so increased in numbers that they have taken the first place in the fishery of the Adyar estuary in September-October 1963 in August-September 1964 and in February-March 1965 when the prawn fishery has been poor due to the closure of the bar. The Tilapia fishery has undoubtedly proved a valuable a sset to the otherwise small earnings of the fishermen of the Adyar estuary during the lean months caused by the closure of the bar. The cat fish fishery is also noteworthy i n this respect in that large numbers migrate after rains and floods in June, July-August contributing to the foremost fishery of those months. The mullet fishery cannot be forgotten in that it is a predominant fishery more or less hroughout the year. Whether they breed in the estuary is an interesting subject for investigation considering their importance as a commercial fishery throughout the year.

Conclusion.

The study of the general trend of the fishery of the Adyar estuary shows its complete dependance on the whims and fancies of nature. Introducion of exotic varieties which not only survive but also breed and increase in numbers is one way of solving the problem of low production when there is no marine fishery. A second method is to induce the breeding of the commercially important varieties in estuarine conditions. But this is not an immediate solution as considerable research has to be done to arrive at feasible methods. A more permanent solution to this highly critical problem is necessary as the problem is a basic one and deals with the livelihood of the inland of fishermen of the area. There is every possibility that extreme drought conditions may suddenly prevail completely drying up the esturine waters in which case the above two methods will be of no avail. Something has to be done before such exigencies arise. It is imperative that permanent connections of the estuary with the sea are made in spite of the trouble and money involved. A permanently open bar, an estuary filled with tidal waters and a rich harvest of marine fish and prawns throughout the year will be one step in solving the food problem.

Acknowledgments.

Thanks are due to Kumari C. Durga, former Laboratory Assistant, Adyar, for analysing the water and soil samples.

Referances.

1. Abraham, J. G. 1931. A survey of the hydrobiolgy and fisheries of the Cooum river. Madras Journ. Fisheries Volume 1, 50–69.

2. Chacko, P. I. and Ganapati, S. V. 1949. Some observations on the Adyar river with Special reference to its hydrobiological conditions. Indian Geogr. Journ., 26, 1–15.

3. Chacko, P. I., Srinivasan R., George S., Krishnamurthi, B. and Ganesan R. A study of the hydrobiology and fisheries of the Adyar estuary with special reference to conservation contribution. Freshwater Fisheries Biol. Station, Madras No. 11.

4. Chacko, P. I. and Krishnamurti, B. 1954 Observations on Tilapia mossambica Peters in Madras J. B. N. H. S. Vol. 52 Nos. 2 and 3.

5. Chacko, P. I. and Venkataswamy A. D. 1958 Development of Brackishwater Fisheries in Madras State. Ind-Com Journ. Vol. XII No. 1 157–159.

6. Peter Devadas, D. D. and Chacko, P. I. 1953 Introduction of the exotic crehlid fish, Tilapia mossambica Peters, in Madras Cur. Sci. 22, 29.

7. Tampi, P. R. S. 1959. The ecological and fisheries characteristics of a saltwater lagoon near Mandapam Journ. M. B. Assoc. Ind. Vol. No. 3.

TABLE 1.

Meteorology for 1963-64—Adyar Estuary.

Months.	*Air temperature.*		*Relative humidity.*	*Weather condition.*	*Remarks.*
	Maximum.	*Minimum.*			
(1)	(2)	(3)	(4)	(5)	(6)
			PER CENT.		
April, 1963	30°C	28°C	86	Showers for 3 days	....
May	31°C	28°C	71	Bright sun	Bar closed on 4th May 1963.
June	31°C	30°C	94	Rain for 6 days	....
July	31°C	30°C	88	Rain for 26 days	....
August	30°C	28°C	88	Rain for 20 days	....
September	28°C	27°C	92	Cloudy, rain for 6 days	....
October	28°C	27°C	87	Rain for 2 days	Bar opened on 21st.
November	27°C	26°C	86	Rain for 2 days	....
December	25°C	24°C	91	Bright sun	....
January, 1964	24°C	23°C	91	Do.	....
February	26°C	25°C	91	Do.	....
March	28°C	27°C	91	Do.	....

TABLE 2.

Meteorology for 1964-65—Adyar Estuary.

Months.	*Air temperature.*		*Relative humidity.*	*Weather conditions.*	*Remarks.*
	Maximum.	*Minimum.*			
(1)	(2)	(3)	(4)	(5)	(6)
			PER CENT.		
April, 1964	30°C	28°C	88	Bright sun	....
May	31°C	30°C	85	Do.	....
June	31°C	30°C	88	Hot sun	....
July	29°C	28°C	92	Rain for 12 days	....
August	28°C	27°C	92	Cloudy	....
September	29°C	26°C	77	Rain for 3 days	Bar opened on 5th September 1964.
October	29°C	28°C	81	Heavy rain for 2 days	....
November	26°C	24°C	78	Rain for 15 days	....
December	25°C	24°C	82	Rain for 3 days	Bar closed on 30th January 1965.
January, 1965	26°C	24°C	74	Bright sun	....
February	26°C	25°C	75	Do.	....
March	28°C	27°C	75	Do.	....

TABLE 3.

Hydrography of Adyar Estuary for 1963–64.

(1)	*April* 1963. (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January* 1964. (11)	*February.* (12)	*March* (13)
Salinity°/₀₀	22·84	22·42	..	12·63	14·62	12·12	8·429	12·09	16·283	13·82	15·03	10·5
Oxygen cc/L	4·27	4·41	..	4·2	3·32	3·75	2·25	2·61	3·37	4·48	3·6	4·2
PH	8·6	8·2	..	8·5	8·6	8·5	8·0	7·9	8·1	8·5	8·1	8·3
Carbon-dioxide p.p.m.	Nil	Nil	..	Nil	Nil	Nil	Nil	3·0	2·0	Nil	Nil	Nil
Carbonate p.p.m.	3·0	3·0	..	3·0	3·0	2·5	3·0	2·0	Nil	2·5	2·0	2·5
Bicarbonate p.p.m.	55·51	53·30	..	53·83	49·97	42·76	41·275	36·60	49·81	45·70	57·95	50·33
Silicate Mgm/L	30·0	39·00	..	9·0	12·22	21·25	17·5	14·0	17·67	15·0	18·0	17·0
Phosphate	1·8	1·6	..	0·25	0·4088	0·25	0·8563	0·4266	0·4164	0·4001	0·4237	0·3616
Temperature °C	32·0	31·0	..	26·5	26·5	26·5	26·0	26·0	26·0	26·0	27·0	27·0
Specific gravity	1·020	1·020	..	1·010	1·005	1·005	1·004	1·007	1·014	1·022	1·023	1·023
Turbidity cm.	77·001	40·5	..	53·5	58·7	62·0	64·5	58·5	55·7	48·5	51·0	50·0
Depth in metres	2·251	1·623	..	1·512	1·651	1·766	1·803	1·03	2·048	1·982	1·982	1·893

TABLE 4.

Hydrography of Adyar Estuary for 1964–65.

(1)	*April* 1964. (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January* 1965. (11)	*February* (12)	*March.* (13)
Salinity°°/₀	9·813	10·66	9·701	7·075	4·708	17·91	7·145	3·557	11·266	9·683	8·594	11·10
Oxygen cc/L	3·4	4·2	3·5	3·29	2·8	4·2	4·03	4·7	2·24	2·24	2·8	1·26
PH	8·6	8·2	8·4	8·3	8·4	8·1	8·3	7·8	8·1	8·0	8·2	8·1
Carbon-dioxide	Nil	Nil	Nil	Nil	Nil	Nil	Nil	4·0	Nil	Nil	Nil	Nil
Carbonate p.p.m.	3·0	3·0	3·5	3·0	3·0	3·0	4·0	Nil	2·5	3·0	3·0	3·5
Bicarbonate p.p.m.	48·80	51·85	53·38	51·85	54·9	51·85	42·70	45·75	40·68	30·50	48·80	47·27
Silicate Mgm./L	15·0	15·0	15·0	14·0	17·0	15·0	10·0	18·0	10·0	10·0	10·0	17·5
Phosphate p.p.m.	0·3334	0·4310	0·3592	0·3378	0·3413	0·3522	0·3497	0·3732	0·4049	Nil	Traces	0·25
Temperature °C	30·0	32·°C	28°C	25·5	24·0	23·0	25·5	22·0	24·0	27·0	29·0	27·0
Turbidity cm.	51·0	55·0	53·0	56·0	60·0	55·0	50·5	45·0	38·0	48·0	48·0	40·0
Specific gravity	1·026	1·028	1·027	1·026	1·025	1·023	1·025	1·022	1·025	1·019	1·020	1·028
	1·816	1·715	1·575	1·512	1·651	1·54	1·651	1·918	2·07	1·855	1·778	1·6

TABLE 5.

Soil Analysis of Adyar Estuary for 1964–65.

(1)	*April 1964.* (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January 1965.* (11)	*February.* (12)	*March.* (13)
Chloride P pm.	5	5	5	20	5	5	5	5	150	50	50	50
Calcium	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sulphate	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Phosphorus Act	5	5	2½	1	2½	2½	1	..	2¼	1	1	2½
Phosphorus Res.	..	..	..	..	..	..	..	..	Nil	2½	Nil	1
PH.	..	..	..	..	..	6·5	Above 8.0	6·0	6·5	6·5	6·5	7·0
Ammonia	..	..	..	..	..	..	..	..	Nil	Nil	Nil	Nil
Iron Act.	..	..	..	..	..	..	..	..	Nil	Nil	Nil	Nil
Iron Res.	..	..	..	..	..	..	..	..	Nil	Nil	Nil	Nil
of Magnesium	..	..	..	..	..	..	..	..	Nil	Nil	Nil	Nil

TABLE 6.

Sediment for 1963–1965
(in cubic centimetres.)

Months. (1)	1963–64. (2)	1964–65. (3)	Months. (1)	1963–64. (2)	1964–65. (3)
April	1.65	2·25	October	0·77	3·0
May	2.0	0·6	November	1 65	3·25
June	2·0	0.45	December	1.15	1·4
July	2.45	1.55	January	0·3	4.05
August	1·65	3·05	February	0·6	3·4
September	4·0	2·75	March	0·85	8·25

TABLE 7.

Phyto-Plankton for 1963–64.

Numbers per cubic centimetre. (1)	*April* 1963. (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January* 1964. (11)	*February.* (12)	*March.* (13)
(1) Gyrosigma	4,920	..	120	..	..	..	..	..	..	120	..	..
(2) Navicula	1,680	120	3,720	..	..	..	..	..	..	..	..	4,680
(3) Rhizosolenium	6,000	..	12,360	60	..	..	..	..	..	..	..	..
(4) Chaetoceras	174,000	..	16,560	6,600	..	..	..	1,23,800	31,800	..	..	..
(5) Spirulina	12,480	33,000	5,400	660	..	..	..	120	120	..	..	..
(6) Oscillatoria	..	120	1,560	120	..	..	..	..	..	..	120	120
(7) Cosmarium	..	..	..	..	120	..	..	..	..	..	..	..
(8) Diploneis	..	..	..	..	..	120	..	..	..	..	..	..
(9) Thallassiosira	..	..	..	..	..	..	5,400	120	..	1,320	..	..
(10) Trichodesimium	..	..	..	..	..	..	120	..	..	..	..	..
(11) Microcystis	..	..	..	..	..	..	960	3,360	240	6.480	..	3,960
(12) Merismopedia	..	..	..	..	..	..	..	..	..	..	..	240
(13) Melosira	..	..	..	..	..	..	..	45,360	..	120	..	..

TABLE 8.

Phyto-Plankton for 1964–65.

Numbers per cubic centimetre. (1)	*April* 1964. (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January* 1965. (11)	*February.* (12)	*March.* (13)
(1) Nitzchia closterium	1,080	..	..	..	..	..	..	..	..	..	..	..
(2) Spirogyra	240	..	120	..	..	..	..	..	120	1,080	..	..
(3) Microcystis	24,000	360	15,120	14,520	8,400	24,000	16,800	1.800	..	..	120	360
(4) Spirulina	720	..	1,320	..	..	....	2,160	43,208	31,560	2,51,280	61,800	2,10,000
(5) Chaetoceras	39,000	..	24,000	..	..	..	..	..	90,000	13,200	..	..
(6) Oscillatoria	..	..	120	..	..	..	840	79,201	840	17,280	19,800	..
(7) Melosira	..	..	18,000	..	..	..	840	..	360	..	..	..
(8) Rhizosolenium alata	..	..	..	..	..	..	..	..	240	..	..	..
		..	..	..	..	..	600	..	..	120	..	..

TABLE 9.

Zoo-Plankton for 1963–64.

Number per cubic centimetre (1)	*April 1963.* (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January 1964.* (11)	*February.* (12)	*March.* (13)
(1) Nauplii	16,920	6,120	19,200	3,600	10,920	16,080	3,120	1,920	120	2,160	38.760	9,720
(2) Copepods	7,440	8,400	5,640	1,380	840	120	2,520	..	360	3,240	840	1,680
(3) Peridinium	..	120	2,080	..	..	..	..	120	..	..	120	..
(4) Brachinus	..	..	8,160	9,840	..	1,560	2,400	18,240	1,560	..	3,840	120
(5) Ciliate	..	..	7	..	..	..	..	..	..	..	..	..
(6) Polychaete post larvae	..	..	360	..	..	..	..	..	..	..	..	..
(7) Spionid larvae	..	..	240	1	..	..	..	..	..	240	..	..
(8) Gastropod-post larvae	..	..	120	..	..	..	..	..	..	..	120	360
(9) Mesopodopsis	..	..	..	46	525	240	17	..	..	..	..	1
(10) Amphipods	..	..	..	3	..	..	..	..	..	..	2	..
(11) Gambusia	..	..	..	..	..	..	2	..	..	3	..	
(12) Penaeus indicus fry	..	..	..	..	..	..	1	..	..	..	..	..
(13) Lamellibranch post larve	..	..	..	..	..	..	..	240	..	..	..	..
(14) Mysis	..	..	..	..	..	..	..	..	..	6	1	..
(15) Oryzias	..	..	..	..	..	..	..	..	..	..	..	3
(16) Medusae	..	..	..	..	..	..	..	..	..	..	..	1,252
(17) Caligus Sp.	1	..	..	..	..	..	..	..	..	..	..	..

TABLE 10.

Zoo-Plankton for 1964–65.

Number per cubic centimetre. (1)	*April 1964.* (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January 1965.* (11)	*February.* (12)	*March.* (13)
(1) Amphipods	3	..	..	..	..	..	..	..	..	..	..	..
(2) Copepods	240	..	360	..	..	480	4,320	16.920	1,680	240	3.480	1,320
(3) Polychaete post larvae	1	..	..	..	..	..	..	..	360	240	480	..
(4) Gastropod post larvae	1	..	..	..	....	..	..	..	240	..	..	..
(5) Mesopodopis	10	..	25	19	64	103	105	..	..	..	..	..
(6) Brachionus	13;560	25,080	18,460	1,560	120	240	840	13.320	5.120	96,360	48.600	4,080
(7) Water beetle	2	..	19	..	..	..	..	..	..	..	..	..
(8) Water bug	1	..	..	..	..	..	..	..	..	..	..	..
(9) Nauplii	..	720	1,080	..	120	..	240	2,880	1,800	4,680	15,600	1,920
(10) Spionid	120	..	..	..	..	..	..	..	240	..	..	..
(11) Vorticella	..	..	240	..	..	..	..	..	..	..	..	..
(12) Peridinium	..	..	..	..	..	..	..	..	2,400	..	..	..
(13) Cypris	..	..	..	..	..	..	..	..	120	..	..	..
(14) Nematode	..	..	..	..	..	..	..	4	..	120	..	..
(15) Mysis	..	..	..	..	..	..	..	..	..	..	..	..
(16) Fish larvae	..	..	..	..	..	..	..	..	..	..	1	..
(17) Aneuria	..	..	..	..	..	..	..	..	..	..	44,400	..

TABLE 11.

Landings for the year 1963–64.

Months. (1)	*Other Fish in Kgs.* (2)	*Prawns in Kgs.* (3)	*Tilapia in Kgs.* (4)	*Crabs in Kgs.* (5)	*Total landings in Kgs.* (6)	*Predominant fishery.* (7)
April 1963	2,110·00	1,261·00	38·0	..	3,409	(1) Prawn. (2) Mullet. (3) Sillago Sihama.
May	1,717·5	2,237·5	..	..	3,955	(1) Prawn. (2) Mullets. (3) Cat fishes.
June	2,473·5	2,246·0	119	95·5	4,934	(1) Prawn. (2) Mullets. (3) Elops indicus.
July	4,589·0	3,752·5	804·5	225·0	9,371	(1) Prawn. (2) Mullets. (3) Tilapia.
August	10,060·0	237·0	2,296·0	2,143·5	14,736·5	(1) Cat fish. (2) Tilapia and Prawns.
September	9,550·5	440·0	3,293·0	482·0	13,765·5	(1) Tilapia. (2) Mullets. (3) Cat fish.
October	17,688·5	400·0	3,290·5	335·0	21,714·0	(1) Tilapia. (2) Mullet. (3) Cat fish.
November	29,512·0	4,395·0	5,879·0	..	39,786·0	(1) Mullet. (2) Tilapia. (3) Cat fish.
December	43,995·0	8,116·0	7,452·0	..	59,563·0	(1) Mullets. (2) Prawns. (3) Cat fish.
January 1964	8,984·5	4,008·5	511·5	..	13,504·5	(1) Prawns. (2) Mullets. (3) Chaetoessus and Cat fish.
February	12,317·5	2,938·5	1,758·5	..	17,014·5	(1) Prawns. (2) Mullets. (3) Tilapia.
March	10,608·5	2,479	1,568·5	..	14,656	(1) Prawns. (2) Mullets. (3) Elops indicus.
Total	153,606·5	32,511·0	27,010·5	3,281	216,409·0	

TABLE 12.

Landings for the year 1964–65.

Months. (1)	*Other Fish in Kgs.* (2)	*Prawns in Kgs.* (3)	*Tilapia in Kgs.* (4)	*Crabs in Kgs.* (5)	*Total landings in Kgs.* (6)	*Prominant fishery.* (7)
April 1964	4,992	268	1,167	..	6,427	(1) Mullets. (2) Tilapia. (3) Cat fish.
May	5,616·5	171	965·5	..	6,753	(1) Mullet. (2) Tilapia and Cat fish. (3) Megalops, gerres.
June	2,410·5	..	622	..	3,032·5	(1) Cat fish. (2) Tilapia. (3) Mullet.
July	2,633·5	..	1,214	..	3,847·5	(1) Cat fish. (2) Tilapia. (3) Mullet.
August	1,778	..	2,370	..	4,148	(1) Tilapia (2) Mullet. (3) Cat fish.
September	2,147	209·5	1,797·5	..	4,154	(1) Tilapia. (2) Mullet. (3) Cat fish.
October	1,103·5	8,743	325	..	10,171·5	(1) Prawn. (2) Chanos. (3) Tilapia.
November	2,703·5	2,884	2,760	..	8,347·5	(1) Prawn. (2) Tilapia. (3) Mullet.
December	8,068·0	693·0	322·5	..	9,083·5	(1) Mullet. (2) Tilapia (3) Prawn and Sillago.
January 1965	2,124·5	840·5	3,001·5	..	5,966·5	(1) Mullets. (2) Tilapia. (3) Prawns and Sillago.
February	4,356·0	565	784·5	..	5,705·5	(1) Tilapia. (2) Mullets. (3) Sillago.
March	2,511·5	159	1,922·5	..	4,593·0	(1) Tilapia. (2) Mullets. (3) Sillago and Cat fish.
Total ..	40,444·5	14,533	17,252	..	72.229·5	

TABLE 13.

Size and percentage composition of fish landed in 1963–64.

	April 1963.		*May 1963.*		*June 1963.*		*July 1963.*		*August 1963.*		*September 1963.*	
	Size in cm.	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Mullets	21·2—46·3	37	15·0—29·1	9	14·0—46·3	8	12·6—30·6	14	13·7—17·5	7	12·3—17·4	15
(2) Cat fishes	17·3—26·5	1	10·6—17·2	1	12·5—17·3	5	10·3—20·4	7	12·7—16·3	22	10·6—17·6	12
(3) Sillago sihama	17·3—29·4	6	16·4—24·6	5	17·5—23·2	3	14·3—18·1	1	13·0—17·4	8	16·5—20·4	2
(4) Latis calcarifer	12·0—16·74	1	24·6—35·3	2	..	..	..	..	25·0—31·4	3	34·7—40·5	4
(5) Engraulis purava	9·2—12·4	1	9·1—12·4	1	..	..	10·7—15·6	2	12·3—16·5	2	14·8—17·3	4
(6) Serranus sp.	39·0—50·3	1	..	..	..	..	..	..	13·2—16·5	1	15·9—18·6	1
(7) Cynoglossus dispar	15·2—19·4	1	14·6—18·6	1	16·5—22·3	4	12·4—18·5	6	13·8—15·4	1	16·8—20·4	2
(8) Chaetoessus nasus	16·4—26·2	3	12·0—17·3	3	12·1—17·4	2	13·6—18·4	4	12·5—16·3	2	15·3—19·6	2
(9) Dussumeria sp.	12·0—34·1	1	..	..	..	..	..	..	..	..	..	..
(10) Elops indicus	93·4—10·6	1	16·7—19·3	1	16·7—24·5	5	14·0—17·3	5	18·7—24·3	1	16·4—22·3	2
(11) Gerres sp.	10·4—15·0	2	7·7—10·6	3	6·6—12·4	2	8·2—10·6	3	7·4—10·5	4	13·6—17·5	2
(12) Chanos	20·4—45·1	1	..	..	18·4—29·2	1	11·5—18·6	2	13·6—17·3	1	17·3—20·4	2
(13) Chrysophrys sp.	12·5—19·3	½	12·5—18·6	1	..	.	..	..	12·4—16·4	3	14·3—18·2	2
(14) Hemirhampus sp.	11·4—17·5	½	11·7—18·3	4	16·4—20·2	4	12·4—16·8	2	13·7—18·4	1	17·4—20·6	3
(15) Equula sp.	3·5—6·1	2	3·2—5·4	1	2·7—4·6	1	2·8—4·2	1	..	..	..	..
(16) Tilapia	12·8—20·5	1	..	..	10·4—14·5	3	7·6—14·3	10	10·5—14·3	15	11·6—15·3	24
(17) Prawns	9·5—16·2	39	7·4—13·8	57	6·5—12·3	50	7·7—12·4	32	6·5—12·4	15	8·4—11·7	1
(18) Platycephalus sp.	20·0—34·1	1	14·6—26·2	3	16·4—25·3	2	18·5—20·7	2	16·4—19·6	6	20·6—24·7	3
(19) Therapon jarbua	..	..	7·5—10·6	1	8·2—10·6	4	6·5—9·8	4	..	..	12·4—15·6	4
(20) Caranx sp.	..	..	13·4—19·2	2	..	..	..	..	14·5—19·4	2	13·6—18·4	3
(21) Etroplus sp.	..	..	..	..	..	..	..	..	..	..	13·6—17·6	1
(22) Polynemus sp.	..	..	16·8—27·3	1	..	..	..	..	19·6—28·5	3	30·5—37·6	4
(23) Crabs	..	..	..	..	14·5—19·3	2	14·1—17·7	3	12·2—16·3	2	15·3—21·7	1
(24) Megalops sp.	..	..	..	..	..	..	14·2—17·6	2	..	..	16·8—22·5	1
(25) Gobius sp.	..	..	..	..	..	..	..	..	13·4—17·6	1	..	..
(26) Sciaena sp.	..	.	..	..	..	..	..	..	..	..	22·6—28·7	1
(27) Otolithus sp.	..	..	..	..	..	..	..	..	..	..	16·3—19·7	3
(28) Scatophagus sp.	..	..	..	..	..	..	..	..	..	..	14·3—16·5	1
(29) Synagris sp.	..	..	..	..	..	..	..	..	..	..	..	..
(30) Etroplus maculatus	..	..	..	..	..	..	..	..	..	..	..	..
(31) Lutjanus sp.	..	..	..	..	..	..	..	..	..	..	..	..

TABLE 13—*cont.*

Size and percentage composition of fish landed in 1963–64—cont.

	October 1963.		November 1963.		December 1963.		January 1964.		February 1964.		March 1964.	
	Size in cm.	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
(1) Mullets	..	..	13·3 —45·4	20	12·2—46·8	20	15·5—34·7	10	15·3—20·2	15	11·4 —32·4	13
(2) Cat fishes	..	..	10·0 —28·3	13	10·6 -16·3	16	11·7—34·2	7	26·3 -30·4	6	19·8 —30·4	8
(3) Sillago sihama	19·6 —22·0	3	16·2- -25·7	25	16·3 —20·7	6	16·3 —20·4	5	18·4 —24·5	5	16·2 —25·3	
(4) Latis calcarifer	..	..	36·5—43·7	1	30·2 —50·3	2	25·3 —50·7	2	35·9 —50·7	..	26·2 —47·5	
(5) Engraulis purava	..	..	12·4—18·5	2	..	..	10·5 —19·3	3	14·2 —17·3	4	..	..
(6) Serranus sp.	16·6 -18·4	1	15·3 -22·7	1	16·5 -19·7	5	14·6—18·7	3	17·0 —21·6	3	15·0 —20·5	3
(7) Cynoglossus dispar	17·6— 20·4	2	14·0—18·7	2	13·6 18·2	1	16·7—20·4	1	16·6 -19·4	2	17·4 —23·1	3
(8) Chaetoessus nasus	..	..	4·5—22·7	3	13·8 -22·6	3	12·3—26·5	7	14·2—19·6	7	14·3—21·2	6
(9) Dussumeria sp.	..	..	..		..	..	..	..	..	..	..	..
(10) Elops indicus	17.4—20·3	3	17.3—30·5	2	24·0—30·4	3	16·1—35·4	3	19·6 -22·7	2	..	..
(11) Gerres sp.	13·0 —15·2	3	9·0—16·8	0·5	10·5—18·6	2	10·5 17·8	2	10·6 - -14·6	1	11·3—16·4	4
(12) Chanos	18·6 -20·4	3	16·6—20·5	2	19·6—28·7	2	17·4— 38·6	3	16·3—19·0	2	16·6—20·1	2
(13) Chrysophrys sp.	13·6 —18·5	2	15·2—19·4	0·5	17·2 -24·3	2	15·1—20·4	1	15·2 —20·6	2	15·4 —19·2	2
(14) Hemirhampus sp.	..	..	12·4—22·7	6	17·4—19·5	5	17·0—20·7	3	17·5—20·6	2	17·2 —21·5	5
(15) Equula sp.	4·6—5·2	2	..	..	3·5—4·6	1	3·0 —4·7	3	3·1 —5·2	2	..	..
(16) Tilapia	15·3—18·4	16	5·2—22·3	15	13·6—18·4	12	11·6 —19·5	4	13·2 —20·7	10	13·2 —20·6	6
(17) Prawns	10·6—12·4	2	7·0—10·6	9	9·5—12·4	15	6·0 —14·0	26	11·6 —17·4	18	9·7 —15·1	14
(18) Platycephalus sp.	..	..	16·3—30·8	3	18·4—26·8	3	18·3—27·4	3	18·4 -23·6	3	18·6—25·2	3
(19) Therapon jarbua	..	.	8·7—13·6	4·5	10·0 —14·2	1	94·—14·7	2	..	..	8·7—12·4	3
(20) Caranx sp.	15·4—17·3	1	..	..	..	..	16·5—20·3	2	12·4—16·5	2	12·4—17·5	3
(21) Etroplus sp.	..	..	14·2—22·4	0·01	10·7—20·5	1	16·3—21·6	1	15·0—22·7	2	13·2—17·5	2
(22) Polynemus sp.	..	..	15·4—20·7	1	..	..	27·7—40·8	2	31·7—42·5	4	21·7—38·6	2
(23) Crabs	16·6—19·3	1	29·5—46·5	..	28·7—32·4	3	..	..	..	..	..	..
(24) Megalops sp.	..	.	15·8—25·3	1	..	..	15·5— -26·8	4	21·6—26·4	3	20·2—26·8	4
(25) Gobius sp.	13·6—15·0	1	..	..	18·6—22·8	1	12·4—17·5	1	16·5—20·7	1	..	..
(26) Sciaena sp.	18·7—22·7	3	14·2—22·4	..	14·2—19·4	0·5	20·4—28·7	1	..		..	..
(27) Otolithus sp.	20·4—24·6	2	..	..	..	..	..		..		..	..
(28) Scatophagus sp.	..	..	..	..	..	..	..		..		..	..
(29) Synagris sp.	44·6—55·7	2	..	..	..	..	..		..		..	..
(30) Etroplus maculatus	..	..	3·0—5·7	4	..	..	..		..		..	..
(31) Lutjanus sp.	..	..	..		..	..	13·7—17·6	1	14·5—17·3	2	14·0—16·4	3

TABLE 14.

Size and percentage composition of fish landed in 1964–65.

	April 1964.		*May* 1964.		*June* 1964.		*July* 1964.		*August* 1964.		*September* 1964.	
	Size in cm.	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*	*Size in cm.*	*Per cent.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Gerres filamentosus	9·7—16·3	7	10·4—14·6	8	10·1—17·4	4	..	..	..	..		..
(2) Cat fishes	12·5—19·4	11	12·5—30·7	10	11·4—27·5	23	13·5—24·6	50	..	..	15·3—24·1	19
(3) Tilapia	12·1—21·5	14	15·2—20·4	10	12·5—20·1	22	12·7—21·4	30	13·5—22·7	59	12·7—20·5	39
(4) Prawns	8·7—16·4	3	10·2—17·4	2	..	..	..	..	..	..	3·0—5·2	5
(5) Chaetoessus nasus	12·6—18·7	9	12·6—20·2	7	13·5—24·6	6	..	..	15·3—20·6	4	12·4—17·5	3
(6) Elops indicus	16·1—22·5	5	17·5—27·3	2	..	..	..	..	..	..	..	..
(7) Hemirhampus sp.	14·5—19·6	2	..	..	..	..	..	..	..	..	..	..
(8) Mullets	15·2—40·6	27	17·4—46·5	28	15·4—47·2	20	17·6—35·1	13	19·6—37·5	21	16·5—31·7	21
(9) Platycephalus insidiator	18·2—24·3	2	18·7—26·1	2	18·7—26·5	3	..	..	..	..	..	..
(10) Chrysophrys sp.	16·5—20·0	1	16·1—20·4	3	12·5—25·3	2	..	..	..	..	..	..
(11) Polynemus sp.	27·4—46·7	2	21·7—46·8	4	21·8—50·2	6	..	..	..	..	..	..
(12) Latis catcarifer	36·6—65·1	3	30·5—59·4	5	25·5—54·3	2	..	..	..	..	..	..
(13) Etroplus sp.	14·3—19·6	1	13·8—21·6	1	13·2—21·6	2	..	..	..	..	..	..
(14) Sillago Sihamma	15·6—27·3	2	18·5—27·4	1	..	..	..	..	..	..	..	..
(15) Caranx sp.	17·4—25·1	1	15·4—25·3	3	..	..	..	..	..	..	..	..
(16) Lutjanus sp.	40·5—80·6	1	..	..	..	..	..	..	..	..	..	..
(17) Teuthis java	12·6—28·4	1	..	..	..	..	..	..	..	..	..	..
(18) Chanos	40·3—65·4	1	..	..	..	..	..	..	..	..	..	..
(19) Megalops	29·4—37·5	5	19·6—30·4	8	14·8—25·7	6	19·6—26·8	4	20·7—28·4	1	21·6—29·3	2
(20) Serranus sp.	18·7—29·4	1	15·3—26·4	2	..	..	..		..	..	..	..
(21) Therapon jarbua	10·7—17·1	1	10·5—14·3	3	7·6—14·3	4	10·3—14·5	3	10·6—12·3	2	10·4—12·0	4
(22) Gobius sp.	..	..	..	..	..	..	..	..	..	..	13·6—17·5	5
(23) Equula sp.	..	..	..	..	..	..	..	..	..	..	3·2—4·3	1

TABLE 14—*cont.*

Size and percentage composition of fish landed in 1964–65—cont.

	October 1964.		*November* 1964.		*December* 1964.		*January* 1965.		*February* 1965.		*March* 1965	
	Size in cm. (14)	*Per cent.* (15)	*Size in cm.* (16)	*Per cent.* (17)	*Size in cm.* (18)	*Per cent.* (19)	*Size in cm.* (20)	*Per cent.* (21)	*Size in cm.* (22)	*Per cent.* (23)	*Size in cm.* (24)	*Per cent.* (25)
(1) Gerres filamentosus	..		..		..		..		..		7·7—11·5	4
(2) Cat fishes	..		9·5—2·4	1	..		15·4—20·6	6	..		16·3—22·4	7
(3) Tilapia	12·4—15·5	3	12·4—20·5	33	..		9·5—18·5	14	10·7—17·4	50	11·2—17·4	42
(4) Prawns	1·3—7·4	86	6·4—10·5	35	..		11·3—17·4	10	90·7—16·5	14	10·3—18·6	3
(5) Chaetoessus nassus	..		8·4—11·6	4	..		12·6—20·4	9	11·3—18·7	5	11·4—15·7	6
(6) Elops indicus	..		..		..		..		16·5—21·6	1	13·5—19·2	2
(7) Hemirhampus sp.	..		10·7—13·1	2	14·5—17·6	2	11·4—19·6	4	..		..	
(8) Mullets	9·4—17·6	1	21·5—32·7	16	13·2—19·4	24	14·7—47·0	18	12·6—45·2	15	9·2—30·5	16
(9) Platycephalus insidiator	..		..		17·5—24·7	2	18·3—27·4	4	..		17·5—28·6	4
(10) Chrysophrys sp.	..		..		..		..		..		12·5—16·3	3
(11) Polynemus sp.	..		..		15·2—27·6	3	20·2—30·5	7	18·7—30·4	4	19·0—30·1	6
(12) Latis catcarifer	..		..		..		14·6—50·8	7	17·5—47·6	4	..	
(13) Etroplus sp.	..		..		..		..		..		..	
(14) Sillago Sihamma	..		..		11·6—25·5	8	13·6—14·5	10	14·2—35·6	4	12·5—26·4	7
(15) Caranx sp.	..		..		10·3—15·4	2	12·6—20·4	3	11·4—19·3	3	..	
(16) Lutjanus sp.	..		..		..		..		..		..	
(17) Teuthis java	..		..		..		..		..		..	
(18) Chanos	4·5—9·1	10	7·3—10·7	6	8·5—11·8	2	12·4—16·5	3	..		..	
(19) Megalops	..		12·4—15·3	3	12·7—16·4	4	13·5—18·6	3	..		..	
(20) Serranus sp.	..		..		..		..		..		..	
(21) Therapon iarbua	6·1—7·5	Rare.	..		..		7·8—12·1	2	..		..	
(22) Gobius sp.	11·6—14·5	Rare.	..		..		..		..		..	
(23) Equula sp.	..		..		..		..		..		..	

TABLE 15.

Average number of nets used per day in 1963–64.

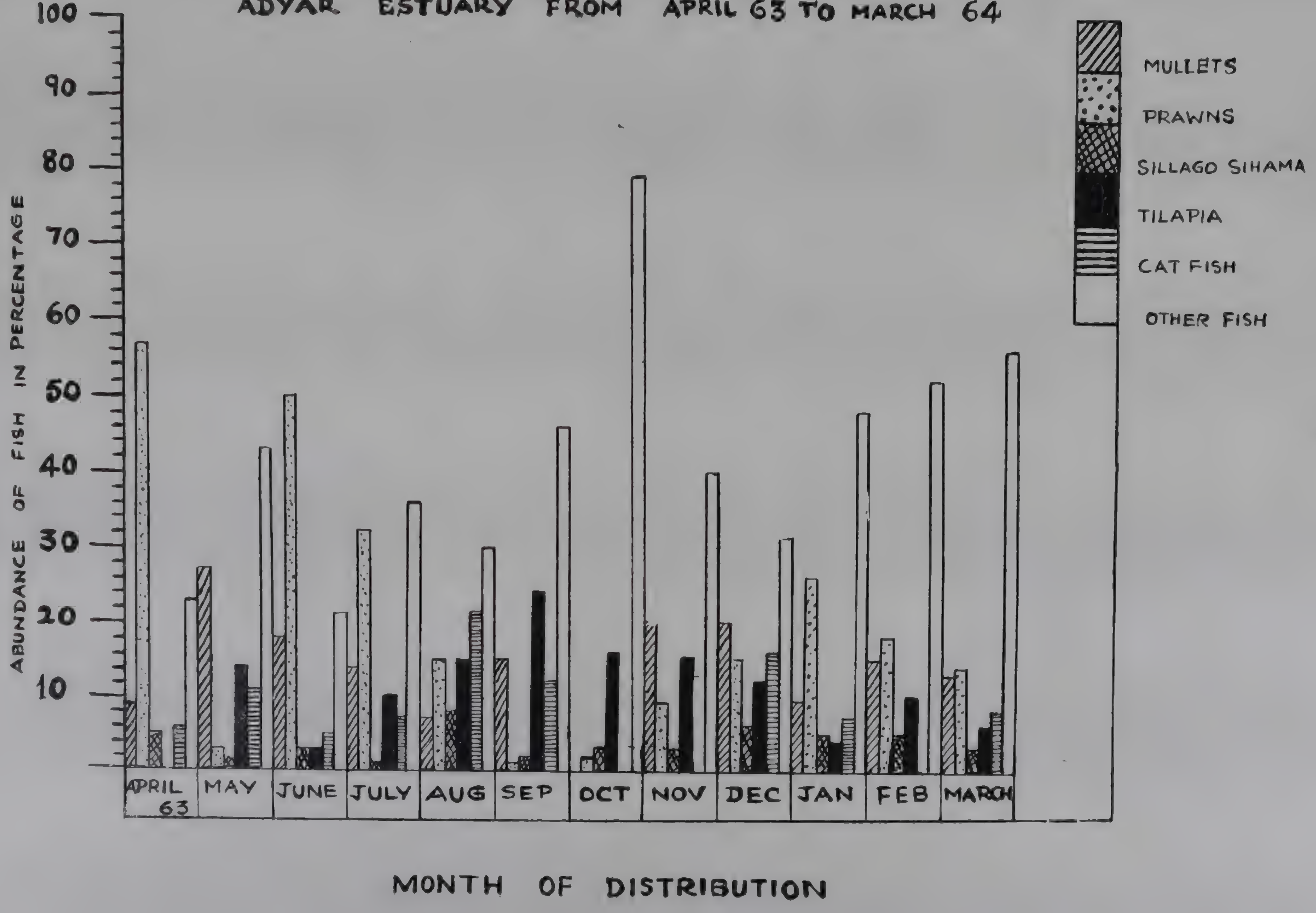
	April 1963.	*May* 1963.	*June* 1963.	*July.* 1963.	*August* 1963.	*September* 1963.	*October* 1963.	*November* 1963.	*December* 1963.	*Jan.,* 1964.	*Feb.,* 1964.	*March* 1964.
(1)	(2)	(3	4	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13
Cast net	10	19	11	20	25	28	26	30	23	22	30	37
Kondavalai	5	1	3	5	4	3	5	6	4	2	3	3
Rod and Line	Nil	2	..	..	9	11	10	5	8	9	8	6
Siruvalai	4	1	3	4	4	5	5	3	3	2	3	3
Kanni valai	Nil to 1	..	..	..	..	..	..	..	..	..	..	..
Poovalai	Nil to 1	..	..	..	..	Nil to 1	1	1	2	..	..	..

TABLE 16.

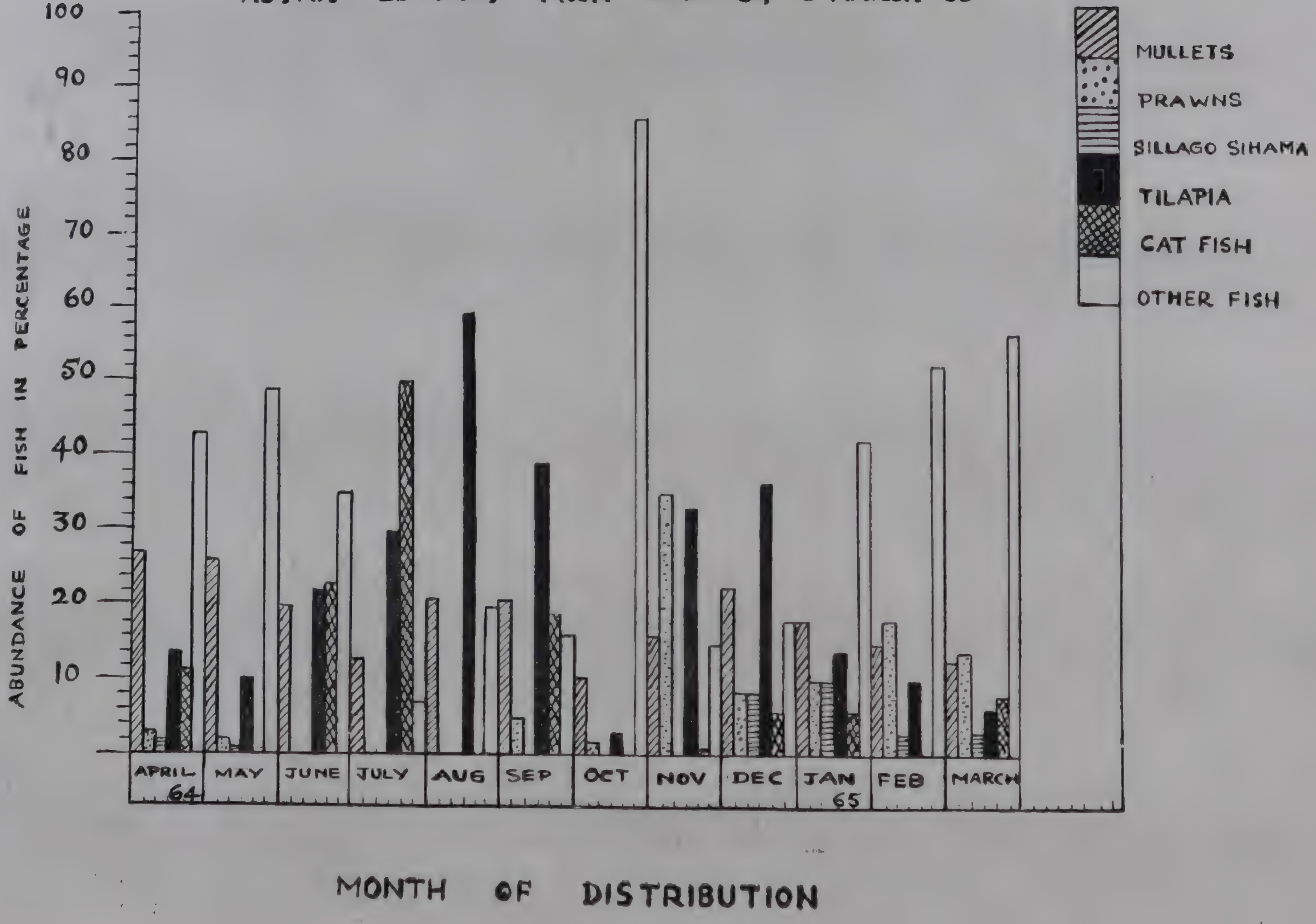
Average number of nets used per day during 1964–65.

	April 1964.	*May* 1964.	*June* 1964.	*July* 1964.	*August* 1964.	*September* 1964.	*October* 1964.	*November* 1964.	*December* 1964.	*Jan.,* 1965.	*Feb.,* 1965.	*March.* 1965.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Cast net	12	12	10	8	13	10	4	10	10	1[illegible]	5	8
Kondavalai	4	2	2	2	..	2	8	3	1	2	1	1
Rod and Line	4	4	7	..	..	..	..	..	7	7	4	5
Siruvalai	3	2	2	3	4	3	1	2	2	Nil to 1	1	2
Kannivalai	..	..	..	..	..	..	..	..	..	..	..	..
Poovalai	Nil to 1	..	..	..	..	..	..	Nil to 1	Nil to 1	..	..	..

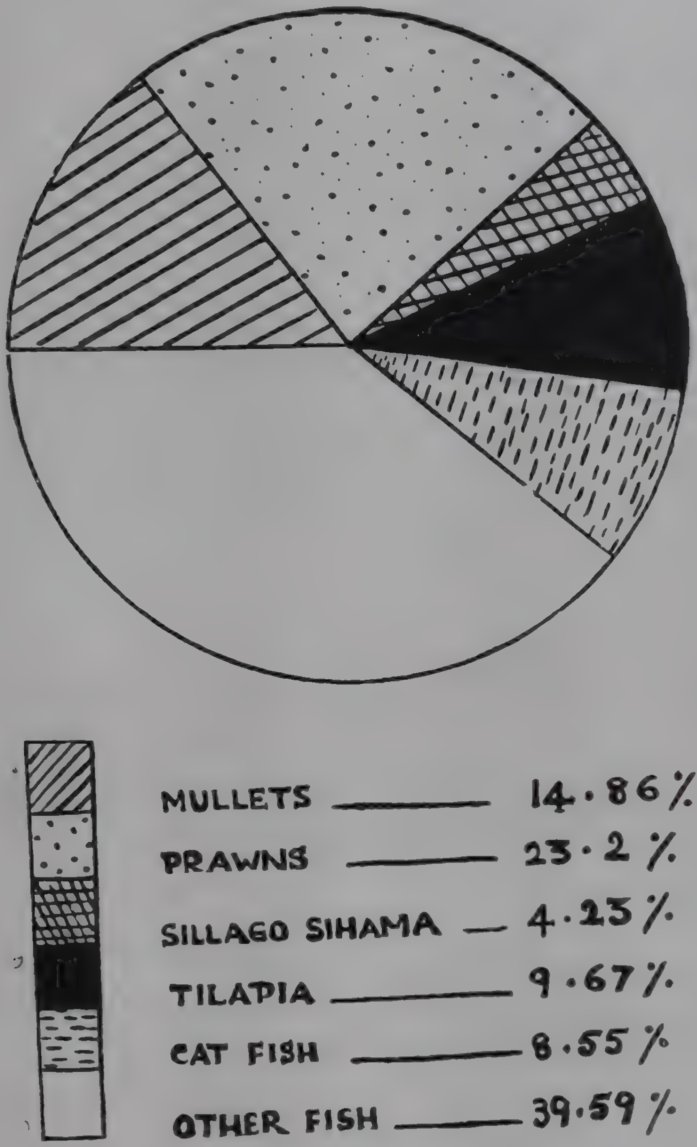
1 HISTOGRAM SHOWING THE MONTHLY DISTRIBUTION OF THE MAJOR FISHERIES OF THE ADYAR ESTUARY FROM APRIL '63 TO MARCH '64



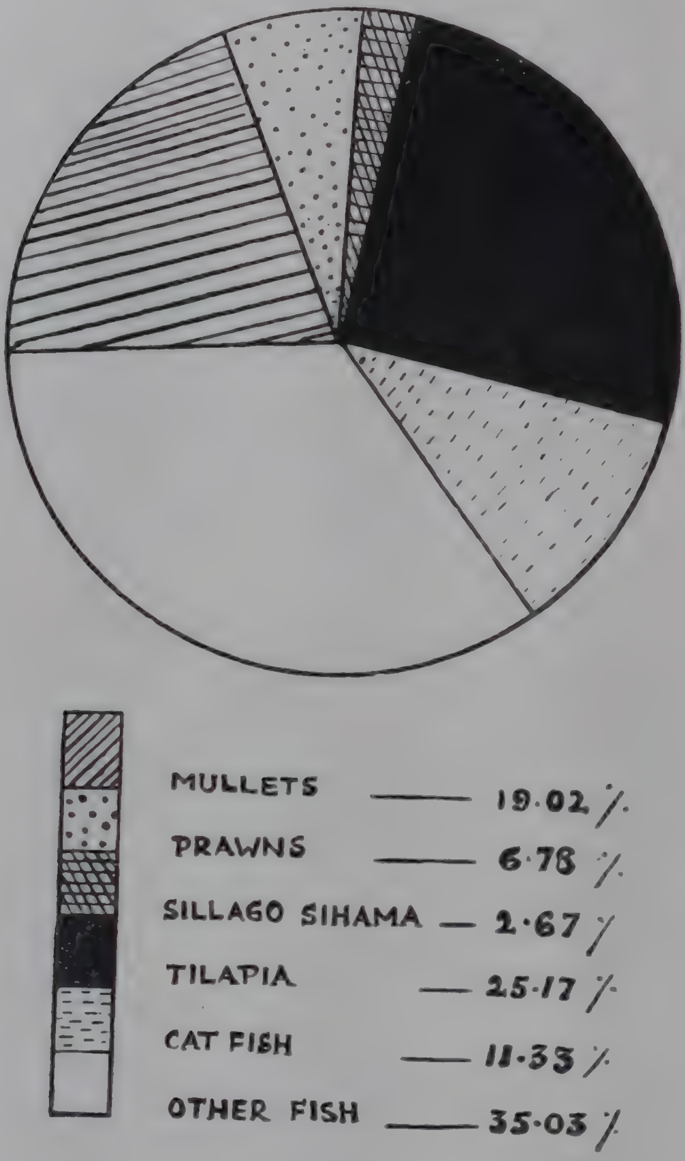
2. HISTOGRAM SHOWING THE MONTHLY DISTRIBUTION OF THE MAJOR FISHERIES OF THE ADYAR ESTUARY FROM APRIL '64 TO MARCH '65



PIE DIAGRAM SHOWING ANNUAL DISTRIBUTION OF THE MAJOR FISHERIES OF THE ADYAR ESTUARY FOR THE YEAR 1963-64.



2. PIE DIAGRAM SHOWING THE ANNUAL DISTRIBUTION OF THE MAJOR FISHERIES OF THE ADYAR ESTUARY FOR THE YEAR 1964–65.



SALINITY AND TEMPERATURE VARIATIONS OVER PEARL AND CHANK BEDS OF TUTICORIN.

BY

FREDA CHANDRASEHARAN, A. D. ISAAC RAJENDRAN AND C. MALU PILLAY.

Introduction.

The temperature and salinity variations in the sea are to a large extent responsible for the general distribution, migration and relative abundance of organisms. The pioneering work in this field in Indian waters has been that of Sewell (1929) who, as early as in 1925, has made extensive observations in the seasonal variations of surface temperature and salinity of the Bay of Bengal. Subsequently similar work has been undertaken by many workers at various places along the east coast of India. Jayaraman (1951–1954) has given an account of the chemistry of the waters off Madras City during the period March 1948 to July 1949 and off Mandapam for the year 1951 and 1952. La Fond (1954) has made detailed studies on the seasonal cycle of sea surface temperatures and salinities along the east coast of India. Chacko, Valson and Malu Pillai (1954) have made observations on meteorology and hydrography of the Kundugal Gut in the Gulf of Mannar. Recently Raghu Prasad (1957) has dealt in detail with the seasonal variations in the surface temperature of sea water at Mandapam from January 1950 to December 1954. Malu Pillai (1963) has made a preliminary study of certain aspects of physico-chemical characters over pearl and chank beds off Tuticorin.

The present study deals with the salinity and temperature variations of the surface waters over the pearl and chank beds off Tuticorin coast for a period of five years from January 1959 to December 1963.

Topography of the area under study.

The region from where water samples were collected were from pearl and chank beds of the central division of the Gulf of Mannar which extends between 8° 55′ and 8° 20′ N. Latitude and 78° 10′ and 78° 25° E Longitude. These beds are situated roughly in line parallel with and at a distance of seven miles from land. The depth of the area ranges from 7 to 8 fathoms. The surface of these beds consists of rock formed by consolidation of sand and dead corals *in situ*. Occasionally the calcite contains varying amounts of quartz sand. The river Tamiraparani falls into the sea near Punnakayal about 30 miles south of Tuticorin.

The two important winds that influence this region are the North-East winds (locally known as Vadai Kondal) which prevail from the month of October to March and the South-West winds (Chola Kachan) which generally start from April and last until about October. Average annual rainfall for Tuticorin is 600 m.m.

Materials and Methods.

Water samples were collected from various pearl and chank beds and analysed for its salinity value. The temperature was recorded at the time of collection. The chlorinity determination was made by Knudsen's method. Standard sea water of chlorinity 19·379 per thousand obtained from the Hydrographical Laboratories, Copenhagen was used for comparison. Salinity values were read directly from Knudsen's tables.

Results.

The monthly average surface temperatures and salinity for the years 1959–63 are furnished in Appendices I and II and are also represented by graphs. (Fig. 1 and 2). During the period 1959–63, samples were not collected in the months of June, July and August 1962 and May 1963.

(*a*) *Temperature*.—It is seen from the graphs that the monthly average temperature was uniformly low in the beginning of the year. Lowest temperature was recorded in the month of January in the years 1960, 1961 and 1962 and in the month of December in 1959 and in the month of February in 1963. The temperature increased from this low level up to May when the highest temperature was reached in all the years. Following the summer maximum in May there was a fall in the average temperature in the months of June and July. The temperature again slightly increased resulting in a secondary maximum in September or October. By November the temperature again recorded a decrease reaching a minimum in December or January.

From the above it can be seen that the temperature fluctuation follows the same general pattern year after year during the five years under study. Similar pattern in temperature variations have been reported in the sea off Mandapam (Prasad, 1957).

During the period 1959 to 1963 the highest surface water temperature 30·6 degree centigrade and lowest temperature 25·6 degree centigrade was observed in May 1961 and January 1960 respectively. Prasad (1957) recorded the highest surface temperature of 32·3 degree centigrade in May 1951 and the lowest of 23·5 degree centigrade in January 1950 during the period 1950–54 in the sea off Mandapam.

The difference between the highest and lowest temperature varied from year to year. Thus for 1959, 1960, 1961, 1962 and 1963 the respective values were 5·3 degree centigrade, 5·2 degree centigrade, 5·1 degree centigrade, 6·9 degree centigrade and 4·1 degree centigrade.

However the annual range in the mean monthly temparature was more or less uniform. The ranges were 4·5 degree, 4·1 degree, 4·5 degree centigrades for 1960, 1961 and 1962.

(*b*) *Salinity.*—In contrast to the striking seasonal pattern of temperature graphs, the salinity graphs show significant annual variations.

Salinity is low in the beginning of the year for all the years under study. Up to June salinity steadily increases as that of temperature. From June onwards marked variations are noticed in the different years under study. In the year 1959 a sudden steep fall in salinity from 34·3 per thousand in June to 30·2 per thousand in July were observed. It is very interesting to note that salinity again increased to 33·5 per thousand in August. Such a low value of 30·2 per thousand was never realised in July in all the years under study. In the year 1960 and 1961 also a slight fall in salinity was observed in the month of June and July respectively. In 1963 such decline in salinity in June, July was not seen. However from August onwards the salinity was high and almost constant and reached a maximum either in September or October. By November the salinity again decreased and reached a minimum in December or January.

The highest average salinity of 35·9 per thousand was recorded in November 1961 and the lowest of 27·45 per thousand in December 1962. During the period of five years under study 1959–63, the lowest individual salinity of 29·13 per thousand was recorded on 5th December 1962 in Thollayiram par and the highest of 36·12 per thousand on 1st September 1961 in Thollayiram par.

The annual range in the mean monthly salinity was highest in the year 1962 the range being 7·9%. For the year 1959, 1960, 1961 and 1963, the range was 5·3%, 3·4%, 3·3% and 3·3% respectively.

Discussion.

(*a*) *Temperature.*—The average maximum and minimum temperature of air recorded at Tuticorin are also plotted to study the relationship between the atmospheric temperature and surface temperature of the water. The maximum and minimum temperature graphs almost follow a similar pattern, the difference between the maximum and minimum temperatures being higher during summer and minimum during winter.

The mean atmospheric temperatures was invariably higher than the water temperature except on a few occasions. During April, November and December 1960, it was lower and also during November 1961, April and October 1962, January and February 1963.

In general the water temperature follows the mean atmospheric temperature. However, certain variations also occur. After reaching the peak in May the water temperature drops to a low level but the air temperature continues to increase till June, after which only it drops.

The increase in surface temperature from January to May is due to the gradual summer heating and the decline in temperature after October is due to the onset of the cold weather and the commencement of the North East winds.

The decline in temperature in June, July has been observed by many workers in the east-coast of India (Jayaraman 1954; Prasad, 1957, and Sewell, 1932). The lowering o temperature in June and July has been attributed to th upwelling of waters from the sub-surface layers by Murth and Ganapathi (1954) in the sea off Visakhapattinam Though the air temperature at Tuticorin was high th decline in water temperature in June may be due to th onset of the south-west winds which causes lowering th temperature due to evaporation.

(*b*) *Salinity.*—The seasonal variations in salinity ar influenced to some extent by the current system prevailing in these waters. There are two currents in this regio depending on the two monsoons. During November t March there is the current from the North flowing Sout along the Coromandel coast which brings in waters of lo salinity and temperature from the North. During Apri to October there is the current from South flowing Nort which brings in oceanic water with high salinity and hig temperature.

The average monthly salinity was lowest in winter an highest in August, September and October. The lo salinity from November to February is due to the curren during North-East monsoon period which brings in water of low salinity. These are further reduced by abou 600 m.m. of rainfall, most of which falls between Novembe and January. Salinity minimum was found in th month of December. January, Jeyaraman (1951) als recorded salinity minimum off Madras during December From February to September he noted very little variation. The salinity peak noted by us was in the month of October-November similar to the observations o Jeyaraman (1964) in the Gulf of Mannar off Mandapam Salinity is high from April to October during South-Wes monsoon period except in June or July. The rainfal experienced during South-west Monsoon is small and th decline in salinity cannot be attributed to the rainfal in this region. The current during this period is also fron South to North which brings waters of high salinity only The possible explanation for the dilution and consequen reduction in salinity is due to the influx of fresh wate into the sea from the river Tamiraparani. To sum u salinity during south-west monsoon period is in fluence by the current from South as well as by the influx of fres water by river Tamiraparani.

Summary and Conclusion.

An account of the seasonal and annual variation o salinity and temperature over pearl beds off Tuticorin i the Gulf of Mannar is presented based on observation during a five-year period.

Large seasonal variations of salinity and temperatur exist over these beds. The variations to a large exten are influenced by the changing monsoons, surface current and influx of freshes of rivers into the sea.

Acknowledgment.

Our thanks are due to Thiru A. Sreenivsan, Assistant Director of Fisheries (Hydrology) and Thiru P. I. Chacko, Deputy Director of Fisheries (Marine) for making valuable suggestions in the preparation of this paper.

References.

(1) Chidambaram, K., Rajendran, A.D.I. and Valsan, A.P., 1951 : Certain observations on the Hydrography and biology of The Pearl Bank, Tollayiram Par off Tuticorin in the Gulf of Mannar in April 1949. *Journal Madras University* 21—Pages 48—74.

(2) Ganapathi, P. N. and Murthy, V.S.R., 1954: Salinity and temperature variations of the surface waters off the Visakhapatnam coast—*Andhra University Memoirs in Oceanography*—Series 49, Vol. I—Pages 125—142.

(3) Ganapati, P. N. and Venkata Rama Sarma, D., 1958 : Hydrography in relation to production of Plankton off Waltair Coast—*Andhra University Memoirs in Oceanography*—Vol. II, Series No. 62—Pages 168—192.

(4) Jayaraman, R., 1951: Observations on the Chemistry of the waters of the Bay of Bengal off Madras City during 1948–49, *proceedings Indian Academy of Sciences* 33B— Pages 92—99.

(5) Jayaraman, R. 1954: Seasonal variations in salinity dissolved oxygen and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam—*Indian Journal of Fisheries*—Vol. I—Nos. 1 and 2—Pages 345 to 364.

(6) La Fond E. C. 1958: Seasonal cycle of sea surface temperatures and salinities along the east coast of India—*Andhra University Memoirs in Oceanography*—Series No. 62, Vol. II—Pages 12—21.

(7) Raghu Prasad, R., 1957: Seasonal Variation in the surface temperature of sea water at Mandapam from January 1950 to December 1954. *Indian Journal of Fisheries*—Vol. IV, No. 1—Pages 20-31.

(8) Sewell, R. B. S., 1932: Geographic and Oceanographic Research in Indian Waters VI. The temperature and salinity of the deeper waters, Bay of Bengal and Andaman Sea—*Memoirs Asiatic Society, Bengal,* 9—Pages 57—424.

(9) Strickland, J.D.H. and Parsons T.R., 1960 : *A Manual of Sea—water analyis.*

(10) Viswanathan, R., 1959: Characteristics of sea water off Mandapam 1950-1954—*Journal Marine Biological Association, India* 1(9)—Pages 85-88.

APPENDIX I.

Maximum and Minimum Air Temperature (°C) at Tuticorin (1959—1963)

Month.	1959.		1960.		1961.		1962.		1963.	
	Maximum.	*Minimum.*	*Maximum.*	*Minimum.*	*Maximum.*	*Minimum.*	*Maximum.*	*Minimum.*	*Maximum.*	*Minimum.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
January	29·0	26·7	28·3	26·7	27·8	26·4	26·7	25·5	27·4	26·7
February	29·3	27·2	28·0	26·6	28·14	27·4	27·8	25·1	27·8	25·1
March	30·4	27·6	29·0	28·2	30·0	28·5	29·2	28·2	29·1	28 ·2
April	31·9	29·2	30·4	29·2	31·5	29·9	30·5	29·3	30·2	29·4
May	32·2	29·9	31·1	29·2	32·0	29·9	31·6	30·4	31·1	30·4
June	33·1	30·6	33·0	31·2	31·7	29·8	31·9	30·7	32·1	30·8
July	31·6	30·0	31·2	30·0	31·2	29·0	31·9	30·5	32·1	30· 7
August	32·14	30·2	31·7	30·0	32·3	30·2	31·2	30·0	32·1	30·4
September	31·7	30·2	31·1	29·8	31·8	29·6	31·2	30·0	33·4	30· 0
October	30·7	29·2	30·7	29·0	30·3	28·7	29·0	28·2	31·6	29·3
November	28·4	27·6	27·8	26·7	28·3	26·7	29·0	28·0	28·2	26·7
December	27·9	25·1	28·3	26·7	28·3	27·2	28·2	27·3	28·4	25·1

APPENDIX II.

Surface Temperature (°C) of Pearl Beds off Tuticorin (1959–1963).

Month.	(T°C)				
	1959.	1960.	1961.	1962.	1963.
(1)	(2)	(3)	(4)	(5)	(6)
January	26·9	25·6	26·5	25·8	27·3
February	27·9	26·2	27·2	26·4	27·2
March	28·2	27·3	28·3	28·5	28·55
April	29·5	29·9	29·5	30·3	29·3
May	30·3	30·1	30·7	30·3	..
June	28·1	28·7	27·3	..	28·0
July	28·0	29·5	26·9	..	28·0
August	26·8	27·9	27·9	..	27·9
September	28·1	27·8	27·8	29·0	28·18
October	28·2	28·1	29·3	28·92	28·4
November	26·8	27·9	29·0	28·15	27·9
December	26·5	27·8	27·6	27·7	27·9

APPENDIX III.

Salinity of Surface Waters (parts per 1000) of Pearl Beds off Tuticorin (1959–63)—S%.

Month. (1)	1959. (2)	1960. (3)	1961. (4)	1962. (5)	1963. (6)
January	33·2	32·02	32·15	33·43	31·88
February	34·04	33·61	33·31	33·63	31·91
March	34·44	33·59	33·6	33·58	33·15
April	34·34	34·37	34·11	34·80	33·83
May	34·55	34·77	34·68	34·96	..
June	34·27	33·98	34·88	..	34·88
July	30·2	34·99	33·04	..	34·83
August	33·5	35·39	34·97	..	34·99
September	34·96	35·43	35·44	35·30	34·91
October	35·05	35·26	35·44	35·14	34·86
November	34·03	33·40	35·86	31·21	33·73
December	32·94	32·55	33·65	30·41	31·66

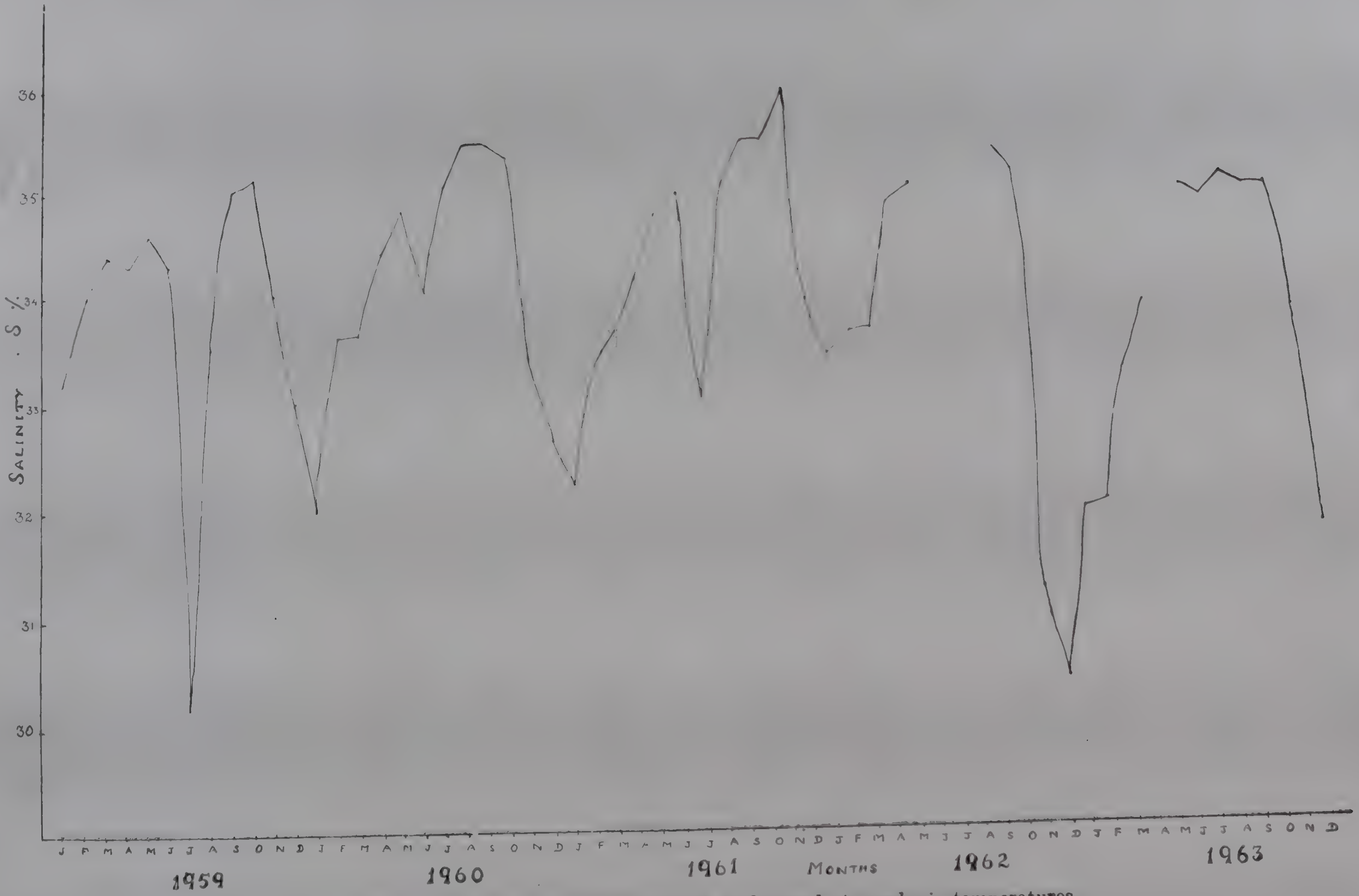


Fig. 1.—Showing the mean monthly surface and atmospheric temperatures.

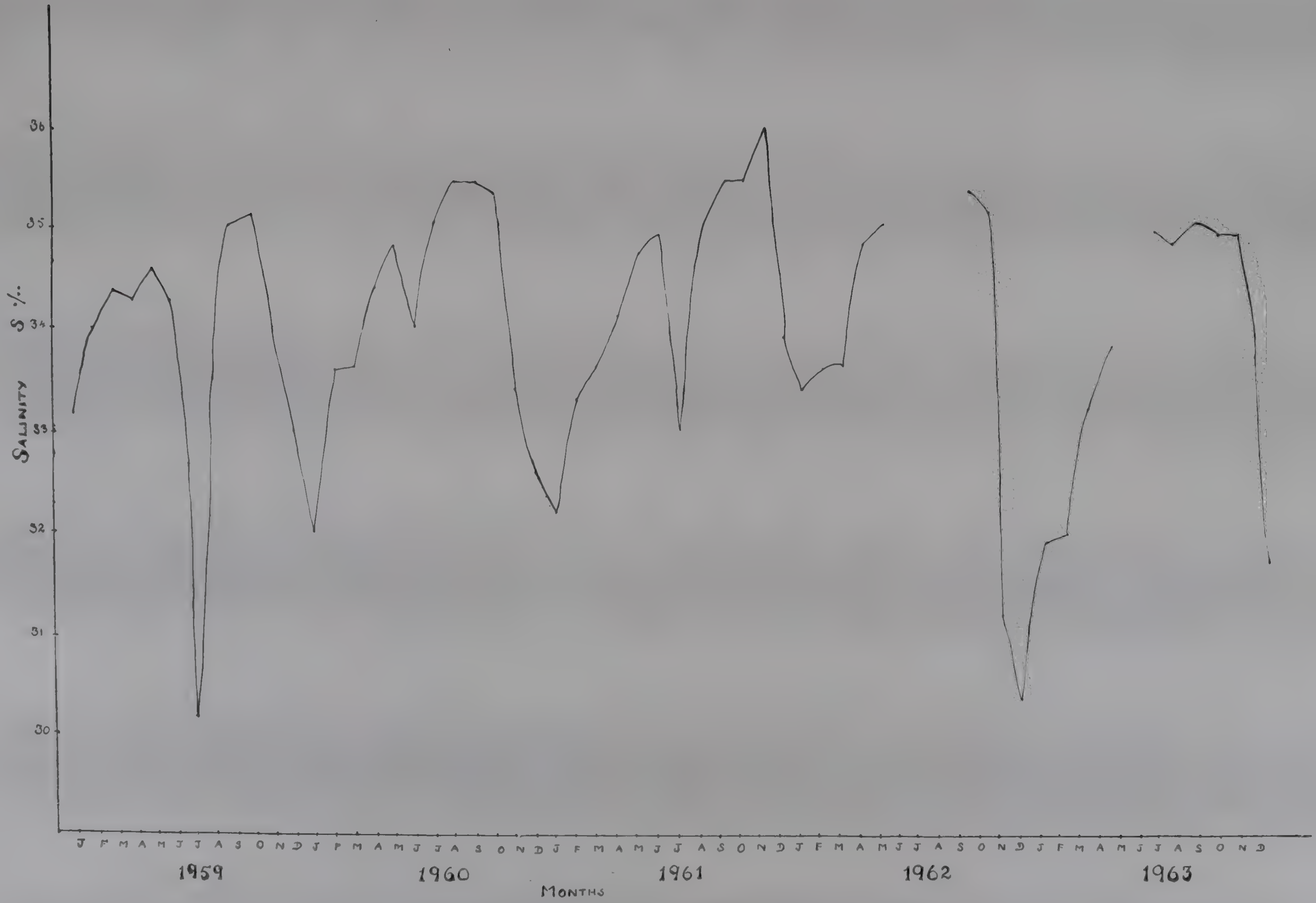


Fig. 2.—Showing the mean monthly variation in Salinity.

OBSERVATIONS ON THE HYDROGRAPHY AND PLANKTOLOGY OF PEARL BANKS OF GULF OF MANNAR.

By

MRS. FREDA CHANDRASEHARAN AND K. SUDHAKAR, MARINE BIOLOGICAL STATION, TUTICORIN.

Introduction

Various workers have investigated the hydrological conditions and planktology of the waters in the Gulf of Mannar. Much of the early studies on plankton and hydrological features in the Gulf of Mannar around Krusadi island has been that of Chacko (1941, 1945, 1950, 1955). Chidambaram (1951) has made certain observations on the hydrography and biology of the pearl bank TholayiramPar from off Tuticorin. Jayaraman (1954) has discussed about the seasonal variation in the hydrological conditions in the sea off Mandapam. The characteristics of Marine plankton and its fluctuation off Mandapam have been dealt by Raghu Prasad (1954, 1956). Recently Malu Pillay (1962) has described in detail the physico-chemical conditions of Indian Pearl Banks from December 1958 to May 1959. Sambandamurthy (1962) has given a preliminary account regarding the fluctuation of surface plankton of pearl bank, Tholayiram Par, Tuticorin.

In the present investigation a preliminary qualitative and quantitative study on plankton of pearl banks of the Central Sector (from Vaipar in the North to Manapad in the South) has been made with relation to physico-chemical condition for the period November 1965 to October 1966.

Materials and Methods

The Indian Pearl Banks of the Central Divisions of the Gulf of Mannar lie between 8° 55′ and 8° 20′ N latitudeand 78° 10′ and 78° 25′ E. longitude. These banks extend within the 11 to 15 miles limit from the shore and the depth varies from 7 to 12 fathoms (14 to 22 meters).

A plankton net made of bolting silk, with a ring 18″ diameter was towed along the surface for 15 minutes during the morning hours between 8-30 and 9-30 a.m. with a vessel moving at an average speed of 2 knots per hour. The collections were immediately preserved in 5 per cent formalin. Simultaneously the water samples were collected using Knudsen's reversible water-bottle and the temperature of water was recorded from the reversible thermometer.

The quantity of plankton was estimated by volumetric method by allowing the sample to settle in a graduated measuring cylinder. The sediment of the plankton was made up to a known volume and one c.c. was taken for analysis. The quantitative analysis of planktonic forms were made with the help of a counting chamber. Salinity, silicate and phosphate were estimated by the methods suggested by Harvey (1945).

Observations

The results of enumeration of occurrence of the planktonic organisms are furnished in Table I. Noticeable fluctuations were seen in the volume of plankton in different months of the year. It varied from 14 c.c. in December to 59 c.c. in July. Two maxima were observed in June, July and in March.

The diatom flora of pearl banks was mainly represented by *Rhizosolenia*, *Trichodesmium*, *Coscinodiscus*, *Thallassiothrix* and *Biddulphia*. Two outbursts of phytoplankton, one in March-April and the other in September-October were noticed, *Trichodesmium* and *Thallassiothrix* appeared in blooms during the summer months of April and May. *Rhizosolenia* was prominent in September–October and to a lesser extent in March-April. *Coscinodiscus* though in small quantities, were observed throughout the year. *Biddulphia* were present in the months of January, April and October.

Noctiluca and *Ceratium* were the common representatives of *Dinoflagellates*. *Ceratium* was found in considerable quantities in all the months whereas *Noctiluca* appeared in appreciable numbers only during the month of September and October.

Copepods mainly constituted the group *crustacea*; and they occurred in all the months, being abundant during January, June, July and August. The nauplius and zoea larvae were found in considerable quantities in June and July. *Phyllosoma* larvae of lobsters and larvae of crabs were noticed in fewer numbers in some of the samples. The other important *crustacean*, *Lucifer* was observed in large quantities during May.

Chaetognaths were represented by species of *Sagitta* in all months but were abundant during the early part of the year. They were observed in swarms from January to May.

Oikopleura was noticed in large quantities in May. From June to September they were absent. *Salpa* was found in large numbers in April.

Observation of the veliger stage of *lamellibranchs* in January was an interesting feature. They were totally absent in other months. Gastropod larvae were observed in small numbers in all the months except February and March.

The spionid larvae of *polychaetes* were noticed in all months but were plenty during September.

Except in July fish eggs were found in small quantities throughout the year. Fish larvae were also seen throughout the year except in November and December.

The annual range in the monthly mean temperature on this coast was 3·5 degree centigrade. The monthly average surface temperatures are shown in Fig. 1. The temperature showed two peaks, the primary one reaching up to 29·8 degree centigrade in April and the secondary one upto 28·2 degree Centigrade in October. The low temperatures recorded were during December to February and December recording the lowest temperature of 26·3° C. for the year. In June-July a fall in temperature was noticed. The double oscillation of sea water temperature is characteristic of sea water in the east coast of India (Chidambaram—1950, Jayaraman—1954; Chacko—1956).

The monthly average salinity of sea water are represented in Fig. 2. The lowest salinity was recorded in January and from then onwards it gradually increased and reached a peak in October. The maximum salinity was 34·8 per thousand and minimum was 31·6 per thousand the annual range being 3·2%. High values of salinity were observed during south-west monsoon and lower values during north-east mansoon season. The low salinity recorded in north-east monsoon season is not only due to the rainfall at the time but also due to the current from the north, which brings in waters of low salinity.

The monthly average silicate content of the surface waters varied between 4 Mgmat L to 44 Mgmat L. The silicate content was comparatively high during the south-west monsoon period May to September and low during north-east monsoon period. The lowest value was recorded in November and April. Silicate concentration was maximum in June.

Discussion

The above results reveal that the zooplankton attained its peak development immediately following the peak in phytoplankton production. The reduction in phytoplankton may be due to the grazing effect produced by zooplankton. Such inverse relationship between phytozooplankton and zooplankton has been observed by Raghu Prasad (1956) also of L in waters around Mandapam.

Temperature is known to play an important part in determining the fluctuations in plankton populations and their distribution. The rate of metabolism and hence the rate of growth and reproduction of any given species is regulated by temperature (Sverdrup, 1942) From the graph it is seen that the total volume of plankton was low during periods of high temperature as is particularly evident in the month of April-May. Likewise the standing crop of plankton was highest when the temperature was lowest during the south-west monsoon period. However, it is of interest to note that phytoplankton was abundant when the temperature was relatively high. Similar observation has been recorded by Raghu Prasad (1956) in waters around Mandapam.

Both the phytoplankton bloom in this area was found to occur when the salinity was high. This appears to be at variance with the observation of Subramanyan (1959) who has recorded that phytoplankton was abundant during periods of low salinity. Phytoplankton reached its maximum in April just before the onset of the south-west monsoon winds in May and during September just before the north-east monsoon winds in October.

Acknowledgment

We wish to thank Thiru P. I. Chacko, Deputy Director of Fisheries for useful suggestions and Thiru Edwin Joseph, Assistant Director of Fisheries, Pearl and Chank for help and encouragement in the preparation of this paper.

References

(1) Chacko, P. I. (1945)—Plankton investigations at the Krusadi Biological Station—Symposium on Plankton Research, Indian Ecological Society, Madras Centre—Pages 1—4.

(2) Chacko, P. I. (1950)—Marine Plankton from waters around the Krusadi Island—Proceedings—Indian Academy Science, XXXL, B.—Pages 162—174.

(3) Chacko, P. I. (1956)—Annual report of the Marine Biological Station, Tuticorin—April 1954 to March 1955. Madras Fisheries Department, Fisheries Station Reports and Year Book 454-55—Pages 37-56.

(4) Chacko, P. I. (1956)—A surface temperature of the coastal waters of Madras State, India, during the sexennium 1949-54, 1954-55, Pages 199-201—Science and Culture 21, 458, 459.

(5) Devanesan, D.W. and Chacko P.I. (1943)—On the fluctuations of a few typical items of planktonic organisms in the sea around Krusadi Island, Gulf of Mannar, for the quinquennium 1936-37 to 1940-41—Proceeding. 31st Indian Science Congress, Part 3—Pages 116–117.

(6) Ganapathy, P. N. and Murthy, V.S.R. (1955)—Preliminary observations on the hydrography and inshore plankton in the Bay of Bengal off Visakhapatnam Coast—Indian Journal of Fisheries, Vol. II, No. I—Pages 84 to 95.

(7) Harvey, H.W. (1945)—Recent advances in chemistry and biology of sea water—Cambridge University Press.

(8) Malu Pillay, C. (1962)—A survey of the maritime meteorology and physico—Chemical conditions of the Indian Pearl Banks off Tuticorin in the Gulf of Mannar from December 1958 to May 1959. Madras Journal of Fisheries, Vol. I—Pages 77 to 95.

(9) Jayaraman, R. (1954)—Seasonal variations in Salinit dissolved oxygon and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam —Indian Journal of Fisheries, Volume I, Nos. 1 and 2— Pages 345 to 364.

(10) Raghu Prasad (1954)—The characteristics of marine plankton at an inshore station in the Gulf of Mannar near Mandapam—Indian Journal of Fisheries, Volume I, Nos. 1 and 2—Pages 1—36.

(11) Raghu Prasad (1956)—Further studies on the plankton of the inshore waters off Mandapam—Indian Journal of Fisheries, Volume III, No. 1—Pages 1 to 42.

(12) Sambandamurthy, P. S. (1962)—Surface plankton of the Pearl Bank Tholayiram Par off Tuticorin—Madras Journal of Fisheries, Volume I—Pages 74 to 75.

(13) Sverdrup. H.U. Johnson, H. W. and Fleming, R. H. (1942)—The Oceans, their Physics, Chemistry and General Biology, New York.

Table I.

Showing the occurrence of planktonic organisms from November 1965 to October 1966.

Serial number and name of organisms. (1)	*November.* (2)	*December.* (3)	*January.* (4)	*February.* (5)	*March.* (6)	*April.* (7)	*May.* (8)	*June.* (9)	*July.* (10)	*August.* (11)	*September.* (12)	*October.* (13)
(1) Rhizosolenia	..	..	P	P	P	C	..	..	P	P	P	P
(2) Trichodesmium ..	..	..	..	..	..	P	..	..	..	..	..	..
(3) Thalassiothrix ..	..	..	..	..	..	B	P	..	..	..	..	..
(4) Coscinodiscus	R	R	R	C	C	P	C	C	C	C	P	C
(5) Biddulphia	..	..	R	..	..	C	..	..	..	..	..	P
(6) Bacillaria	..	..	..	..	..	S	..	R	..	..	..	..
(7) Noctiluca	..	..	..	..	R	C	..	..	..	C	P	P
(8) Ceratium	R	R	C	R	C	C	C	P	P	C	P	P
(9) Temora	..	..	P	P	P	P	P	P	P	P	C	P
(10) Lucifer	..	..	..	C	P	P	P	..	P	..	C	P
(11) Caligus	..	..	..	P	..	C	C	C	P	C	..	..
(12) Sagitta	R	R	P	P	P	P	P	C	C	P	C	R
(13) Salpa	..	..	..	C	C	P	C	..	..	R	..	..
(14) Oikopleura	R	R	R	P	C	C	P	..	..	..	..	C
(15) Medusae	..	R	P	..	C	C	C	P	..	P	P	..
(16) Beroe	..	..	..	C	C	..	..	..	..	..	..	R
(17) Zoea larvae	..	R	C	P	C	C	C	P	P	P	C	C
(18) Nauplius larvae ..	R	R	P	C	R	..	..	P	P	C	P	P
(19) Bivalve Larvae (Veliger).	..	..	S	..	..	..	..	..	..	..	..	..
(20) Gastropod larvae ..	R	R	C	..	..	R	R	R	R	R	R	R
(21) Spionid larvae	..	R	C	C	R	R	..	R	C	R	P	R
(22) Annelid larvae ..	..	..	..	C	..	..	..	R	C	..	..	..
(23) Crab larvae	..	..	C	R	..	..	..	..	..	..	..	..
(24) Fish eggs	R	R	C	C	P	R	C	C	C	C	C	R
(25) Fish larvae	..	..	R	R	C	R	R	C	R	R	C	R
Average volume of the sediment (in c.c.).	33	14	46	37	52	30	21	57	59	15	17	22

R = Rare 1 to 10 individuals per c.c. of sample.

C = Common 11 to 100 individuals per c.c. of sample.

P = Plenty 101 to 200 individuals per c.c. of sample.

S = Swarm 201 and above individuals per c.c. of sample.

B = Bloom.

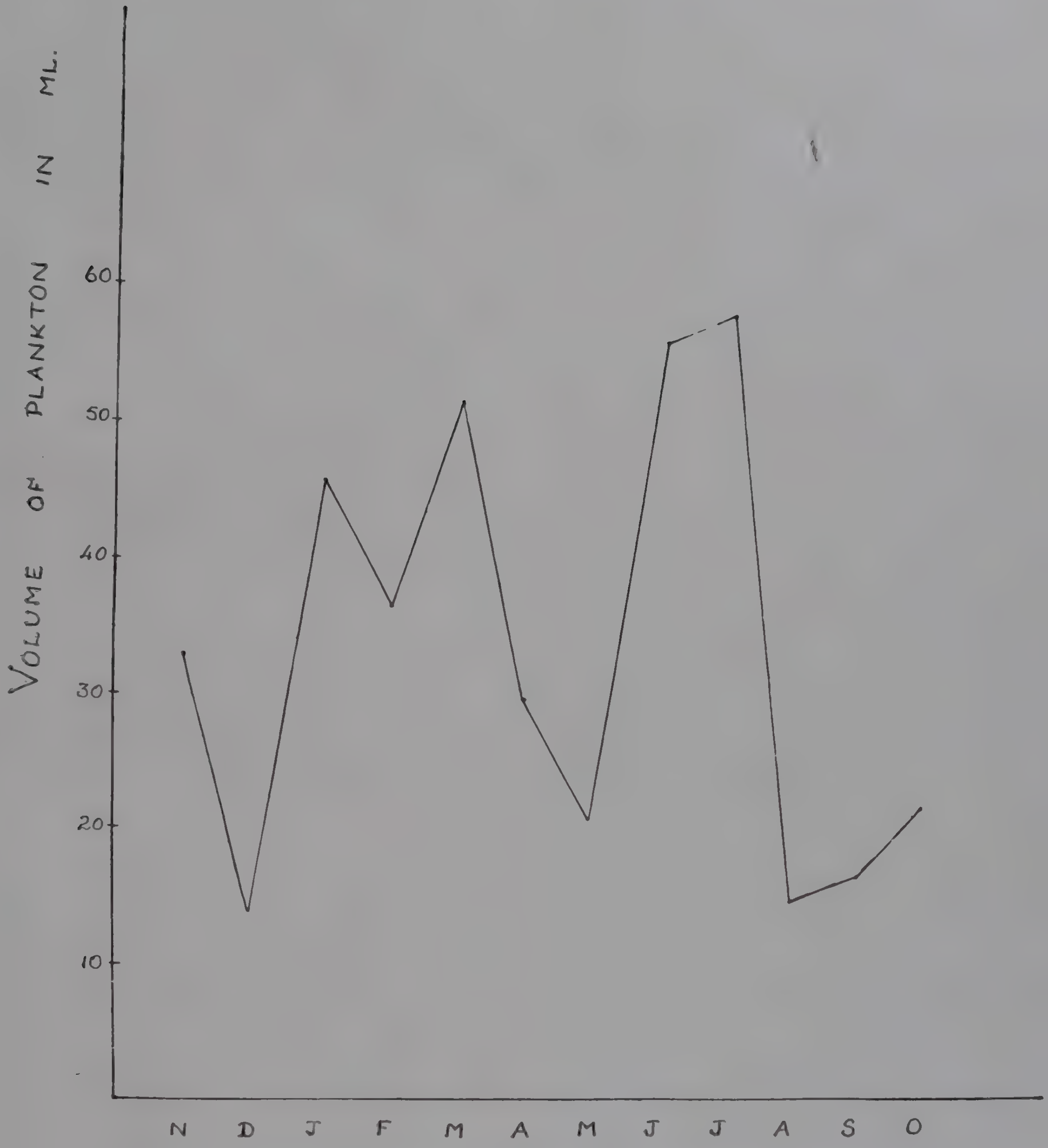


FIG.—1. Monthly variation in volume of the planktonic sediment.

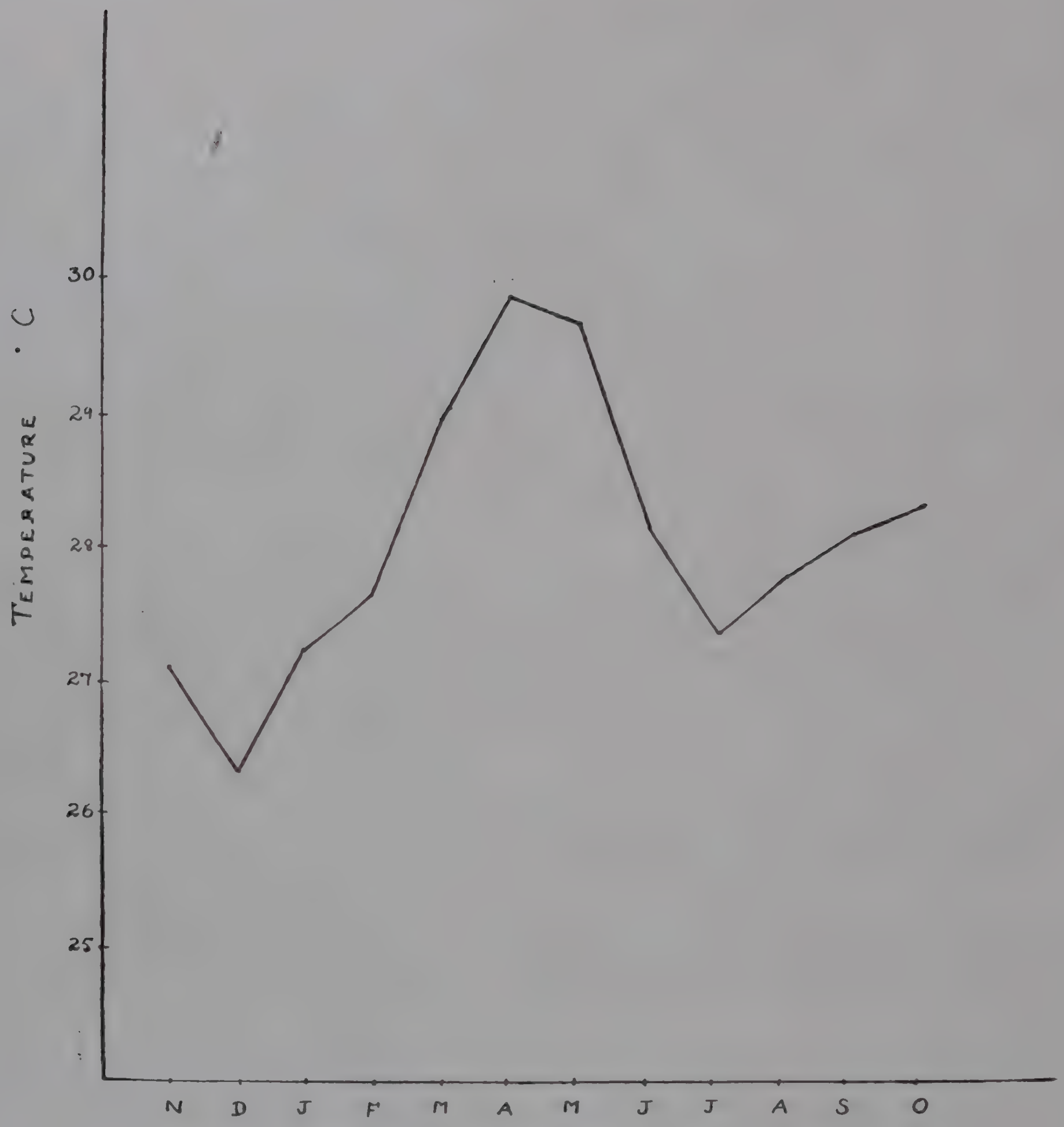


FIG. 2.—Variation in the temperature of sea water (surface).

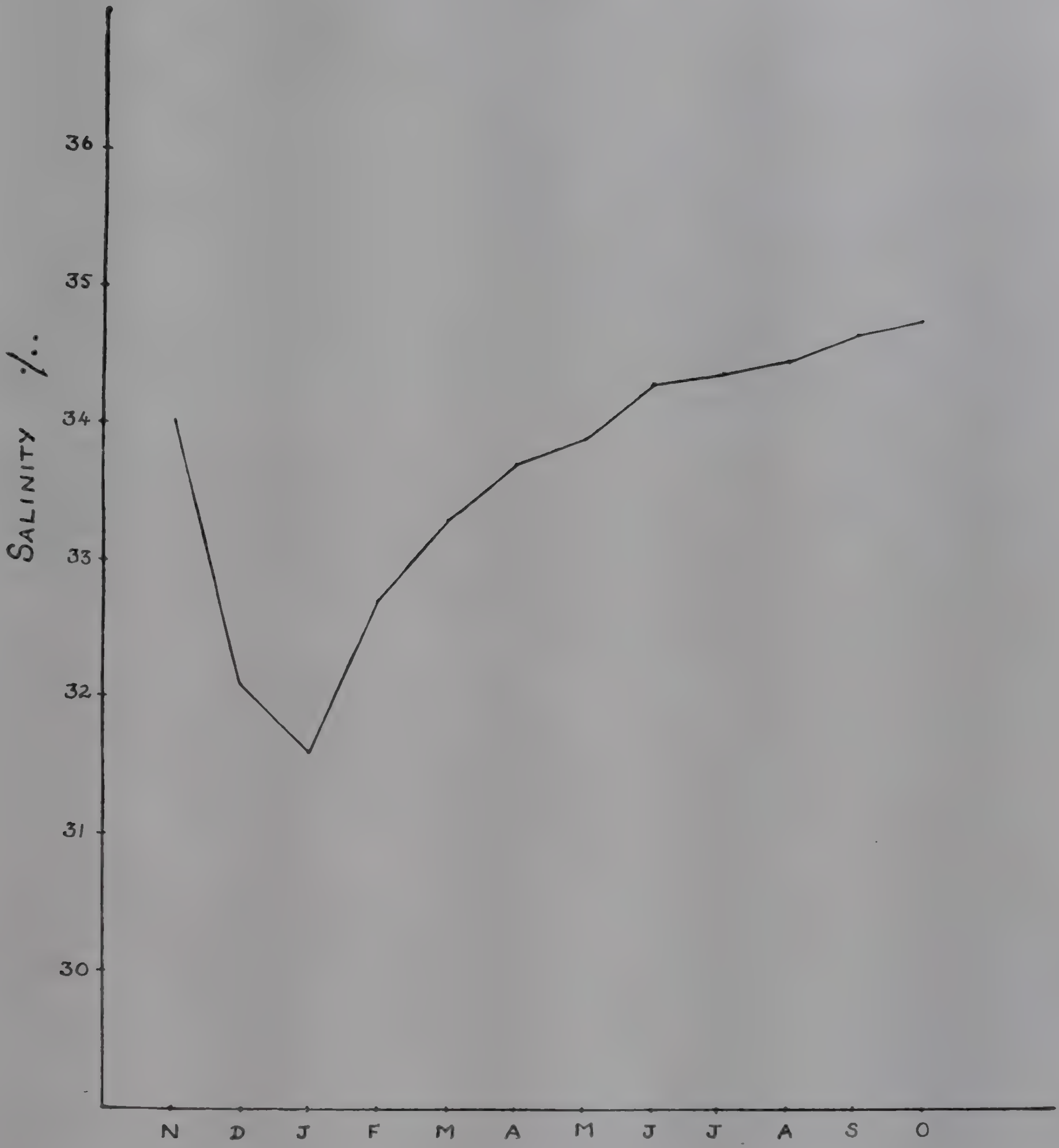


FIG. 3.—Variation in the salinity of the surface water.

THE ELEMENTS OF ADHESIVE DISC OF ECHENEIS AND THEIR HOMOLOGIES.

BY

B. BONNELL AND THMT K. JEYACHANDRAN.

Historical.

Among the labourers in this field the following names stand out: Voigt F. S. 1837; Kner 1860, 1861; Baudelot E. 1867; Beck G. 1879; Niemiec N. J. 1885; Storms R. 1888 and Houy R. 1909. But every one of them seems to have found difficulties in comparing the various skeletal pieces of the disc with the parts of an anterior dorsal fin. In the course of our studies on the functional aspects of the disc, the morphological peculiarities had necessarily to be examined and the derivation appears to be simple and straight forward provided a proper appreciation of the pieces in the disc and their counterparts in the anterior dorsal fin of the teleost is understood. None of the views hitherto expressed appears to be satisfactory and hence this note.

Kner 1860, who interpreted the dorsal spines not as fin rays but as modified scales, felt that the serrations of the transverse folds of the headshield were a hindrance to compare them with the rays of the dorsal fin. The present account shows that it is not so.

Voigt, F. S. 1837, considered the disc as a dorsal fin whose rays are laid apart from one another on both sides and thus becomes backwardly directed transverse plates of the disc. According to this view the rays would have to be formed first before being laid apart.

Beck G. 1879, attempted to explain the homologies but was unable to suppress the doubts he entertained.

Niemiec J. 1885 maintained that it was not possible to establish homologies between the elements of the disc and those of a dorsal fin.

Storms R. 1888 explained that the lamellae might have been formed as the lateral extensions of the bases of the dorsal rays themselves while they were rudimentary. It looks as though, not the bases of the dorsal rays, but the radials on which the dorsal rays stand that undergo extension.

Baudelot E. 1867 held that the view expressed that the disc might be regarded the equivalent of the dorsal fin has not been supported by rigorous determination--certain internal pieces of the disc having remained undetermined.

Houy R. 1909, made a serious attempt to evaluate the views of his predecessors but again he has missed the fact that the teeth should be regarded as a separate entity in the structure of the disc.

With regard to the teeth he says "I have undertaken a most careful investigation of the teeth and have found that we have here nothing of the kind of real teeth. These are more solid structures and are made up of fine concentrically layered substance which pass over insensibly into the substance of the bonytoothed plate so that any kind of movement is just out of question".

(Quoted from translation provided by INSDOC.)

When the lamellar plates are boiled during preparation of the skeleton the teeth drop out, showing, that they are not mere continuations of the bony substance of the tooth bearing pieces. They are implanted in tissue which disintegrates while boiling releasing the teeth. Thus the fact that the teeth form a separate element in the bony frame work was missed. Each tooth appears to be a segmented bit of the lepidotrich.

Homologies.

In the dorsal fin of cartilaginous fishes like the shark a row of pieces form the basalia, the next two rows form the radialia and thirdly the elongated dermotrichia are present. This arrangement of four elements is followed throughout the vertebrate series for all appendages paired and unpaired. Even in the human being the humerus and the femur represent the basals; the radius and the ulna and the tibia and the fibula, the first row of radials; and the carpals and tarsals the 2nd row and the metacarpals, metatarsals and phalanges the jointed dermotrichials.

Goodrich in his account of the median fin of the teleostian fish *Esox lucius* speaks of proximal segment of radial, median segment, distal cartilage and lepidotrich. If the proximal corresponds to the basal of the shark, the median and distal the radials then the lepidotrich will to the dermotrich of it. The accompanying figure (1) helps in comparing the teleostian fin with that of the disc of Echeneis.

In the modified disc of Echeneis the small spine like bones below the disc along the median region would be the basals, the row of flat plates immediately above them the first row of radials, and the lamellar bars, the second row of raidials and the rows of teeth along the border of the second row of radials including the median greatly enlarged tooth called the subtactilodact, the segmented dermotrich or lepidotrich.

New comparison.

It seems to be easy to establish the homologies of the various parts of the disc. Note the distal rounded cartilage placed between the split lower ends of the lepidotrich in Goodrich's figure. If the cartilage grows sideways and carries along with its outer border the tips of the lepidotrich, the segmented parts of the trich will lie on the anterior border of the cartilaginous piece in the same way as it does in the lamellar bar. The basal plates also broaden out along with the rounded cartilages. But the lowest pieces which correspond to the basal of the shark or the first radial, if you speak of three radials instead of two, do not change their shape.

Ontogeny.

John in the account of the early development of Echeneis does not represent a disc on the head of the newly hatched egg. This means that if the larvae is successfully reared all the stages in the formation of the disc can be studied and it would be possible to follow the ontogeny of the development of the disc. This article would help us in finding out how the four skeletal elements are laid and progressively developed. The flattening out of the radial plates, the distribution of the lepidotrich along the border of the second radial can be followed.

Thanks.

My thanks are due to the C.S.I.R. for the grant that they have sanctioned for this study; to the Principal and management of New College who have been good enough to permit me to work in their premises and to my assistant who has prepared all the sectional slides and drawings for my use and is my research fellow.

Bibliography.

Baudelot E. 1867. Etude sur le disque Cephalique des Remoras. Acad. des. Sciences. 18 March pp.—625–627.

Beck G. 1879. On the sucker of Echeneis remora Inaugural dissertation, Bern.

Bonnell B. 1961. Structure and action of sucker of Echeneis. Nature Vol. 191 Page 403, dated July 22.

Bonnell B. 1962. Structure of the sucker of Echeneis. Nature Vol. 196 – page 1114–115.

Bonnell B 1964. Adhesive disk of Echeneis naucrates.
Nature Vol. 203 page 206 July 11.

Bonnell B. 1966. Oval disk of Echenied Fishes. Nature Vol. 212 page 736–737.

Goodrich E. S. 1958 Studies on the structure and development of Vertebrates Vol. 1 Chapters 1–8 page 94.

Has Hans. We come from the sea. Translated from the German by Alan Houghton Brodrick-Jarrolds.

Houy R. 1909 Contributions to the knowledge of the sucker of Echeneis. Zool Jahrb vol. 29, page 108–136.

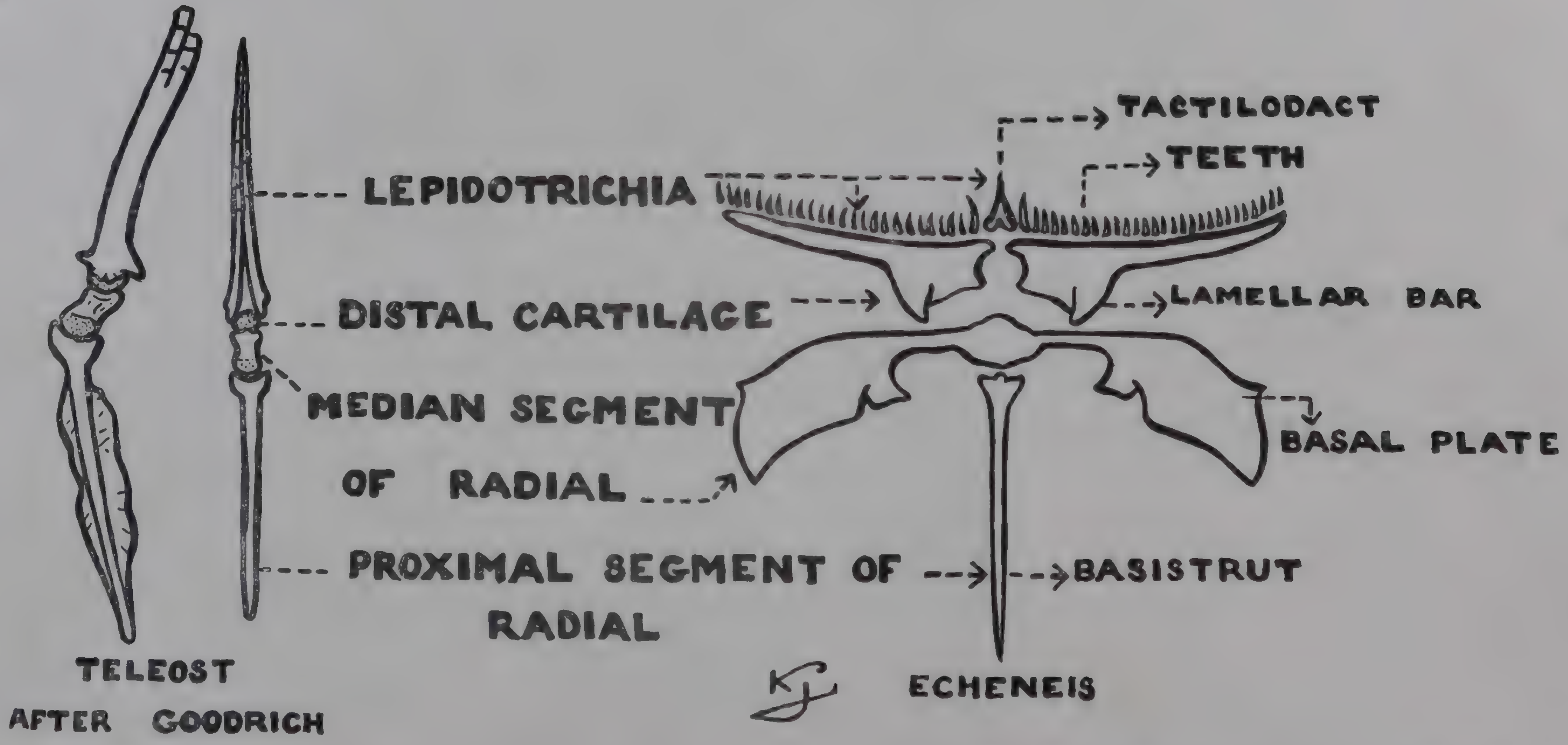
John C. Mary. 1950 Early stages in the development of the sucker fish Echeneis naucrates. Division of Marine Biology and Fisheries, Trivandrum.

Niemiec J. 1885. Morphological researches on the suckers in the animal kingdom in Rec. Zool. Suisse, vol. 2 page 1–148. also dessertations Geneve.

Storms R. 1888. The adhesive dise of Echonies. Ann. Mag Nat. Hist. (6) vol. 2 page 65–76.

Yarrell English Encyclopaedia vol. II Nat Hist page 459.

HOMOLOGIES OF THE ELEMENTS OF THE ADHESIVE DISC OF ECHENEIS


TACTILODACT
TEETH
LEPIDOTRICHIA
DISTAL CARTILAGE
LAMELLAR BAR
MEDIAN SEGMENT OF RADIAL
BASAL PLATE
PROXIMAL SEGMENT OF RADIAL
BASISTRUT
TELEOST
AFTER GOODRICH
KJ
ECHENEIS

The teeth and tactilodact represent the Lepidotrichia, the distal cartilage the Lamellar Bar and the median segment, the Basal plate. The proximal segment of the radial is the Basistrut.

AN UNUSUAL LARGE SCALE MORTALITY OF MARINE FAUNA IN THE SOUTHERN BEACH OF KRUSADAI ISLAND.

BY

K. SUDHAKAR AND S. ANTONY DOSS, MARINE BIOLOGICAL STATION, KRUSADAI ISLAND.

Unusual mortality of Marine Fauna has been observed by Chacko (1942), Chidambaram *et al* (1944) and Chacko and Mahadevan 1952 in the Gulf of Mannar. All the observation were associated with *trichodesmium erythraeum*, Ehrenb, bloom in the sea in the month of May and June in the respective years. This year 1965 during the last week of May *trichodesmium erythraeum*, Ehrenb bloom was observed extensively in sea around Krusadai Island, Pamban and Mandapam. *Trichodesmium* appeared in the sea on 18th May 1965 and continued to accumulate till the characteristic brown colour was observed. During the first week of June, the accumulation of Trichodesmium erythraeum was so much that extensive brownish mats were formed in the sea continuously. During the last week of May the algae slowly began to decay turning brownish and then to dark brown in colour. The slushy dark brown thick liquid was always found in the margin of the beach while the slight pink coloured decayed liquid was found slightly interior in the sea. The bloom of *trichodesmium* lasted for sixteen days starting from 21st May to 5th June 1965 in sea around Krusadai Island. The cause of large scale mortality of marine fauna was attributed to Trichodesmium asphixiating the marine fauna by previous observers.

Several specimens were washed ashore on 2nd June 1965 during this season. They were collected and examined carefully. There was a heavy damage to coral reef fishes due to the putrifaction and pollution of dead algae.

The following specimens were washed ashore during this period :—

1	Squilla rhiphidea	6
2	Squilla sp.	18
3	Holothuria scabra	19
4	Holothuria atra	21
5	Hippolysmata vittatua	22
6	Apenodes vittatua	32
7	Tetrodon nigropunctatus	32
8	Gobius sp.	39
9	**Mureana** polyzoda	**221**

In all these specimens excepting for Holothurians, Trichodesmium erythraeum was found to have clogged the gills. However there was no trace of the algae in the alimentarycanal of the specimens when dissected. Mureana, polyzona were found unusually washed ashore in large numbers (ranging from 5¼ to 12½ in length). The Holothurians washed ashore were buried in the brownish slush. The days during which the mortality occurred were perfectly normal days with reference to the sunlight, temperature, etc. The surface temperature of sea water varied from 29.5°c to 31·3°c during these days.

Excepting for the presence of Trichodesmium chrenb bloom, there was nothing unusual in the sea. In all the specimens dissected and studied Trichodesmium erythraeum was involved in asphixiation. Therefore it was concluded that Trichodesmium was involved in the large scale mortality of Marine Fauna by clogging the gills and by making them foul during its putrefaction. The smell of the purtrifying Trichodesmium erythraeum was so offensive, that it caused headache and uneasiness even in human beings.

Acknowledgment.

On thanks are due to Thiru P. I. Chacko, for his guidance and criticism.

Reference.

1. Chacko, P. I., 1942 ; An unusual mortality of marine fauma ; Proceeding 29th Indian Science Congress, XI, 104.

2. Chacko, P. I., Mahadevan, S., 1956 : Swarming of Trichodesmium erythraeum Eherberg in waters around Krusadi island, Gulf of Mannar ; Madras Fisheries Station Reports and Year Book, pages 139–144.

A NOTE ON THE VELIGER LARVAE IN PLANKTON COLLECTED FROM THOLLAYIRAM PAR.

BY

SUDHAKAR AND MRS. FREDA CHANDRASEHARAN, MARINE BIOLOGICAL STATION, TUTICORIN.

In Plankton sample collected from the Thollayiram Par on 7th January 1966 veliger larvea were found in abundance. Occurrence of veliger larvea in Plankton collection have been reported by Prasad (1954) in waters around Mandapam. Such observation of veliger larvae in Plankton samples collected from Pearl Banks off Tirunelveli coast has not been recorded so far.

The following hydrological conditions prevailed over the par at the time of collection of the plankton :—

	Surface. (1)	*Bottom.* (2)
Depth in meters	..	19
Temperature °c	28.0	27.5
PH.	8·2	8.2
Specific gravity	1·024	1·024
Dissolved oxygen ml/L	4·8	4.8
Salinity$^0/_{00}$	31·42	31·42
Silicate ugm at/L.	8·4	16·6
Phosphnte ugm at/L.	0·4	0·4
Calcium mg. at/L.	10.76	10.76

The surface drift was from north to south and the direction of the wind was North East.

Two hundred larvæ were examined. Their sizes ranged from 243 × 217μ to 365 × 278μ with an average of 315 × 257μ. Each larvae had a distinct triangular shape with an embryonic shell which was transparent at the margin covering the opaque internal soft parts. (Figure. No. 1) The adductor muscles were clearly visible as two oval patches on either side. The embryonic gills also were visible. There was a distinct eye spot situated slightly below the centre of the larvae. The measurements are given in Table 1.

The salient descriptions of some of the larvae commonly known to occur in these waters as detailed by Russel (1963) together with the description of the larvae under investigation are furnished below for comparison.

The larvæ found in the plankton sample from Thollayiram par very closely resemble the larvæ of pearl oyster (Pinctada vulgaris) described by Herdman (1906) and James Hornell (1922) It is therefore assumed that the larvae observed in plankton collection may be the post veliger stage of pearl oysters (Pinctada vulgaris). [The recent Pearl Bank inspection conducted during September 1966 revealed that Thollayiram par which was barren for the past 4 years was replenished with a fresh stock of oysters. This findings strengthens the above view.] Herdman (1906) during his cultering experiments on Pearl oyster found that the youngest fixed larvae of Pinctada Vulgaris measured 400 μ. The largest larvae observed by us measured 365 μ. indicating that larvae found in the plankton sample are at a stage just prior to settlement.

Acknowledgment.

Our thanks are due to Thiru P.I. Chacko for his helpful criticism and suggestions. Our thanks are also due to Thiru S. Edwin Joseph for his guidance and encouragement.

References.

(1) Herdman, (1906)—Report to the Government of Ceylon on the pearl oyster fisheries of Gulf of Mannar.

(2) Hornell James, (1922)—The Indian pearl Fisheries of the Gulf of Mannar and Palk Bay.

(3) Raghu Prasad, 1954 :—The characteristics of marine plankton at an inshore station in the Gulf of Mandapam near Mandapam. Indian Journal of Fisheries Vol. 1, Pages 1—36.

(4) Russell F. S., 1963—Advances in Marine Biology, Vol. 1.

Larvae under description. (1)	*Larvae of Pecten irradians.* (2)	*Larvae of Mytilus.* (3)	*Larvae of Modiolus.* (4)
(1) Eye spot is conspicuous larvae exceeding 200μ.	Eye spot not visible in larvae exceeding 170μ. in length.	Eye spot measuring 5 to 7 μ situated in the centre of the larvae.	
(2) Eye spot is slightly above the lower margin.			
(3) No velum observed in the larvae.			A functional velum is seen in larvae measuring 295 to 305 μ.

Table I.

Measurement of the larvae in μ.

Serial number. (1)	*Length.* (2)	*Width.* (3)
1	330	278
2	312	269
3	287	243
4	324	264
5	290	243
6	312	278
7	312	278
8	312	278
9	312	278
10	330	278
11	348	278
12	290	243
13	312	264
14	290	264
15	330	264
16	290	264
17	330	264
18	348	278
19	330	278
20	330	264
21	330	278
22	312	264
23	312	264
24	312	264
25	348	264
26	330	264
27	365	295
28	290	243
29	365	278
30	290	243
31	330	264
32	290	243
33	278	243
34	330	264
35	290	264
36	290	243
37	330	278
38	365	278
39	348	278
40	312	264
41	348	264
42	312	264
43	304	264

Table I—*cont.*

Measurement of the larvae in μ—cont.

Serial number. (1)	*Length.* (2)	*Width.* (3)
44	330	264
45	304	264
46	330	264
47	290	243
48	243	209
49	330	269
50	348	269
51	312	269
52	304	243
53	304	243
54	312	264
55	348	290
56	304	269
57	304	264
58	290	264
59	348	278
60	348	264
61	348	264
62	312	269
63	312	269
64	312	264
65	304	264
66	330	278
67	312	264
68	304	269
69	304	264
70	312	269
71	330	269
72	304	252
73	348	278
74	365	290
75	330	278
76	304	264
77	312	278
78	365	278
79	304	264
80	348	304
81	330	269
82	365	304
83	304	264
84	348	269
85	269	269
86	365	278

TABLE I—*cont.*

Measurement of the larvae in μ—cont.

Serial number. (1)	*Length.* (2)	*Width.* (3)
87	365	278
88	324	264
89	304	243
90	269	252
91	330	278
92	290	264
93	243	309
94	304	264
95	330	264
96	330	278
97	312	278
98	304	278
99	290	264
100	330	278
101	374	298
102	330	264
103	348	278
104	290	264
105	312	278
106	278	243
107	304	269
108	287	264
109	348	278
110	304	264
111	312	278
112	348	278
113	330	264
114	312	264
115	330	278
116	304	264
117	278	264
118	304	264
119	304	252
120	304	264
121	348	269
122	304	264
123	287	264
124	243	217
125	312	264
126	330	264
127	330	264
128	304	264
129	304	243

TABLE I—*cont.*

Measurement of the larvae in μ—cont.

Serial number. (1)	*Length.* (2)	*Width.* (3)
130	304	264
131	304	226
132	330	269
133	264	209
134	264	243
135	348	278
136	243	209
137	330	264
138	264	209
139	312	264
140	348	278
141	264	243
142	330	264
143	330	264
144	348	278
145	348	278
146	330	278
147	365	278
148	324	278
149	348	278
150	330	264
151	312	252
152	304	264
153	330	264
154	330	264
155	312	264
156	278	243
157	290	243
158	330	264
159	304	264
160	330	278
161	287	243
162	312	264
163	264	243
164	287	264
165	304	243
166	330	278
167	304	264
168	330	264
169	287	252
170	312	264
171	324	269
172	304	264

-ABLE I—*cont.*

Measurement of the larvae in—cont.

Serial number. (1)	*Length.* (2)	*Width.* (3)
173	290	264
174	312	264
175	348	278
176	330	269
177	330	264
178	312	264
179	304	217
180	330	278
181	264	209
182	312	264
183	290	264
184	269	226
185	330	264
186	312	264

TABLE I—*cont.*

Measurement of the larvae in—cont.

Serial number. (1)	*Length.* (2)	*Width.* (3)
187	348	278
188	264	243
189	312	269
190	304	278
191	264	226
192	348	278
193	330	264
194	304	278
195	264	243
196	324	269
197	348	278
198	368	278
199	312	243
200	348	278

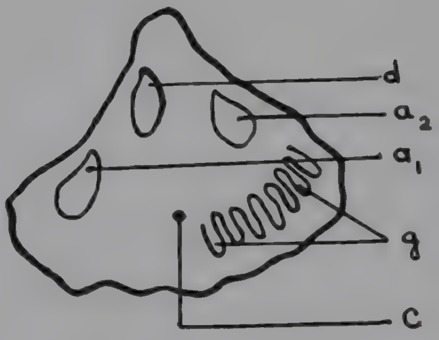


Fig. 1- Veliger larva
d- digestive gland
a_1, a_2 - adductor muscle
g - embryonic gills.
e - eye spot.

SURVEY OF FISHING GROUNDS IN THE INSHORE WATERS OF BAY OF BENGAL NEAR MADRA IN 1965-66.

BY

P. I. CHACKO AND MOHAMMED SULTAN.

A fishing unit commenced survey work in April 1965 with a programme to cover the inshore area of the Bay of Bengal, up to 20 fathoms limit, along the coast of 100 miles of Madras and Chingleput districts, between 12° 30″ N/80° 10″ E and 13° 30″ N/80° 10·25″ E. The area is divided into squares of 25 square miles with reference to longitude and latitude.

The fishing fleet consisted of two numbers of 30 feet (IB) and three numbers (STB) of 32 feet wooden mechanised boats fitted with 24·5 HP Ruston and 50HP Torpedo engines respectively. Each boat had a crew of six. Three types of trawl nets of the following description were operated.

Head rope in feet. (1)	*Foot rope in feet.* (2)	*Head rope.* (3)	*Foot rope.* (4)	*Length of log on each side, feet.* (5)	*Floating material and buoyance in lb.* (6)	*Sinkers.* (7)
55·5	55	½ in dia-manila.	¾ in dia-manila.	5	11 Spherial 5 inches diam-aluminium.	55 barrel shaped leads ½ lb.
57	72·5	Do.	Do.	5	13 Spherical 5 inches diam-aluminium.	60 Barrel shaped leads ½ lb.
60	68	Do.	Do.	6	13 aluminium floats of 5 in diameter.	68 Barrel shaped leads of ½ lb.

Bottom-set gillnets of the following specifications were also operated from these boats.

Mesh sizes, inches—3½, 4 and 4½.
Material—Amilan brand Nylon, 210 x 6 x 3.
Length—25 fathoms.
Depth—10 meshes.
Hanging—50 per cent.
Head rope—½ inch diameter coir rope.
Foot rope—¾ inch diameter rope.
Floats—(*a*) Barrel-shaped Thermocole.
(*b*) 5 inch diameter glass globes.
Weights—Cuddappa stone slabs, 4 lb. each.

During the year 100 square miles covering 13-80-2C and 13-80-3C squares opposite Ennore and Pulicat have been surveyed. Both the squares were found to be suitable for trawling. Their characteristics are as follows :—

(1) 13-80-2C : 2-5 miles off Ennore.

Sandy between 5 and 10 fathoms with rock patch at 7 fathoms; clay between 10 and 15 fathoms; and admixture of clay and mud between 15 and 20 fathoms.

(2) 13-80-3-C : 2-5 miles off Pulicat.

Clay between 5 and 15 fathoms and admixture of clay and mud between 10 and 20 fathoms.

The details of fishing data and catch per effort are given in Table I. It is seen that the average catch per hour with 30 feet boats is 51·2 to 75·8 kg. with gill nets and 13·4 to 29·5 kg. with trawl. In the case of 32 feet boats the catch per hour is 38·3 to 40·1 kg. The earnings per day is Rs. 48·51 with 30 feet boats using gill nets and Rs. 17 to 32 using trawl nets. In the case of 32 feet boats using trawl net, the daily earning is Rs. 47 to Rs. 74.

Particulars of monthwar details of catches are given in Tables II and III. The fishing effort per hour ranged from 2 in December to 134 kg. in October with reference to all fishes. The catches comprised of prawns (9·5 per cent) jew fishes (24·0 per cent), sharks and skates (7·0 per cent), barracuda (5·0 per cent), ribbon fishes (3·0 per cent), soles (0·5 per cent) and other varieties (18·0 per cent).

Though data obtained during the first year of the survey is inadequate for drawing any definite conclusions, the following inferences are of significance.

During the upwelling period, as the fishing data would indicate, the catch per unit effort by trawling is very poor being 13 kg. but fairly good 33 kg. during post upwelling period and good during and after sinking, 40 kg. One of the reasons for the poor catches during upwelling may be attributed to the lifting upwards of the thermocline which may limit the movements of pelagic fishes and to the low oxgencontent and high salinity of bottom waters. The influence of local currents and tidal currents is not ruled out. However from the available data it is inferred that there is a lean period for bottom trawling during upwelling period and it is expected that line fishing or drift net fishing might be more effective during this period due to the presence of thermocline bringing the pelagic fishes near the surface.

Near the shore the phenomena of upwelling and sinking do not seem to have an effect on the demarcation of the fishes except that it may be said that they caused migration towards shore because whatever catches obtained during the upwelling period are from within the range of 0-10 fathoms, specially prawns found in the range of 0-5 fathoms off Ennore.

The average catch per hour by trawling in those two squares already surveyed is only 30 kg. Giving allowances for any fishing error such as engine trouble during operations and thus reducing the efficiency of fishing effort, it is estimated that the production of fish from these two squares by all mechanised boats based at Madras by trawling is 4,000 tons per year. There are 100 mechanised boats out of which 20 per cent only do gill netting exclusively and the rest do mainly trawling but switch on to gill netting also at times. Gill netting is done mainly in these areas beside other areas, all fishing activities being limited up to 20 fathoms. Though all the 30 feet boats of the area are designed for gill netting the tendency for converting them into trawler is growing. Consequently the boats which could go out for gill netting in other areas in the coast sail towards those two squares for trawling.

From the estimated production, the density of fish in those squares of 100 square miles is arrived at 150 kg. per hectare or 60 lb. per acre. It is to be considered whether the density of fish can be allowed to be reduced below 20 lb. per acre. The estimate does not include the fish production by indigenous crafts and gear which if included would give a picture of still less density. The rich nutrient-laden bottom water of the offshore area, the potentialities of the fishing still unexploited in the Bay of Bengal, can very well replenish the stock in the inshore area. The possibility of finding new trawlable grounds is the only course which can allow the introduction of three times the present number of trawlers with the present development of craft and gear technology and harbour facilities.

The survey data also would indicate a trend which would be confirmed or denied by more data in the coming years, that the economic rate of trawling is also getting dissipated among large numbers of fishermen as more and more mechanised boats are introduced and go in for trawling and the only area in the inshore belt available for trawling is those two squares for Madras base. The fishermen invariably work on share basis. They have been trawling in those two squares and if we ignore the difference between fishermen's skill, equipment and luck they would continue until their alternative earnings are equalled by the average product of the fishing.

The economics of trawling (running expenditure only) worked out by the centre is Rs. 20 per hour for a 30-footer and Rs. 26 per hour for a 32-footer. The running time is compounded to actual trawling time. Assuming six hours trawling is done on every fishing day each boat gets an average gross return of Rs. 200 to 220 per day. The net profit per boat is Rs. 80 which being shared by members (as half to owner of the boat and half to all working fishermen). Thus it is seen that a labour fisherman gets an average of Rs. 50 per day if it is worked on labour-share-basis and a member fishermen gets Rs. 10 to 15 a day if it is otherwise. Allowing for depreciation and interest on capital investment and amortisation cost, a fishermen may be earning on an average only Rs. 10 per day.

Fishing being subject to law of diminising returns the survey data would indicate the idea of introducing bigger sized trawlers that would go offshore beyond 20 fathoms with more powerful engine and deck equipments.

TABLE I.

Details of fishing data and catch per effort.

Serial number.	*Fishing boat.*	*Fishing Gear.*	*Actual Fishing days.*	*Actual Fishing hours.*	*Weight of prawns in*	*Weight of cat fish in*	*Weight of Sharks Skates and Rays in.*	*Weight of other fishes in*	*Total catch in*	*Average catch per hour in*	*Amount realised.*
(1)	(2)	(3)	(4)	(5)	(6)	(7	(8)	(9)	(10)	(11)	(12)
					KG.	KG.	KG.	KG.	KG.	KG.	RS. P.
1	I. B. 193	Gill net	10	94	..	5	300	207	512	51·2	475 75
		Trawl net ..	31	31	106	20	366	594	1,086	13·4	538 00
2	I.B. 194	Gill net	10	91	..	105	474	179	758	75·8	509 50
		Trawl net ..	67	247	921	3	486	5,876	7,286	29·5	4,118 25
3	S.T.B. 3	Do. ..	35	107	134	18	217	3,733	4,102	38·3	1,631 70
4	S.T.B. 4	Do. ..	113	381	1,593	31	923	12,834	15,381	40·1	8,365 73
5	S.T.B. 5	Do. ..	59	193	615	16	244	4,721	5,596	29·0	2,868 35
		Total ..	325	1,194	3,369	198	3,010	28,144	34,721		18,507 28

TABLE II.

Month-war catch data showing total catch/Catch per hour.

Month.	*Boat.*	*Fishing effort in hour.*	*All fish catch in*	*Prawns in*	*Silver bellies in*	*Sciaena Jew fishes in*	*Sharks and Skates in*	*Miscellaneous fishes.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			KG.	KG.	KG.	KG.	KG.	KG.
April 1965	I.B. 193, 194 .. —	40	617	123/3·07	62/1·5	123/3·07	..	309/7·7
May 1965	I.B. 194	28	377	..	264/9·4	..	..	113/4
June 1965	I.B. 193, 194	18	434	4/·22	169/9·4	..	43/2·4	18/12·1
July 1965	Do. ..	48	1,074	258/5·4	247/5·2	..	..	569/11·9
Do.	STB. 3	37	999	240/6·5	230/6·2	..	..	529/14·3
August 1965	IB. 193, 194	41	607	64/1·6	229/6·5	..	59/1·2	255/6·2
Do.	STB. 4	41	1,374	50/1·2	480/11·7	35/·85	24/2·3	715/17·4
September 1965	IB. 193, 194	6	124	5/8	95/15·8	..	5/8	19/3·2
Do.	STB. 4	120	4,759	145/1·2	1,657/13·8	856/7·1	332/1·1	1,769/14·7
October 1965	STB. 3,4,5.	134	4,435	174/1·3	2,197/16·4	650/4·9	174/1·3	1,240/9·3
November 1965	Do.	68	3,018	78/1·1	1,235/18·2	..	70/1	1,635/24
December 1965	IB. 194	9	362	..	..	..	..	..
Do.	STB. 4	2	147	..	..	..	..	..
January 1966	IB. 194	84	3,912	570/6·8	1,410/16·8	..	312/3·7	1,620/19·3
Do.	STB. 4	90	4,474	671/7·5	1,611/17·9	..	358/4	1,834/20·4
February 1966	STB. 4	105	2,766	725/6·9	1,023/9·7	..	..	1,018/9·7
March 1966	STB. 4	80	2,954	148/1·9	768/9·6	266/3·3	266/3·3	1,506/18·8

TABLE III.

Statement of fishes available and seasonal variations in yield.

Month.	*Boat.*	*Depth Range (fathoms).*	*Effort in hour in*	*Total catches in*	*Silver bellies in*	*Prawns in*	*Others in*	*Sole in*	*Shark and Skates in*	*Tumbil in*	*Jew fishes in*	*Ribbon fish in*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	8)	(9)	(10)	(11)	(12)	(13)
			KG.	KG.	KG.	KG.	KG.	KG.	KG.	KG.	KG.	KG.
April 1965	IB. 193, 194	5·20	40	617	62	123	309	..	..	..	123	..
May 1965	IB. 193	5·10	28	377	264	..	113	..	..	..	..	..
June 1965	I.B. 194	5·15	18	434	169	4	132	43	43	43	..	..
July 1965	I.B. 194	5·10	48	1,074	247	258	247	..	..	..	161	161
Do.	STB. 4	5·15	37	999	230	240	230	..	..	..	149	150
August 1965	193, 194	5·15	41	607	269	64	..	32	56	84	112	27
Do.	STB. 4	5·15	41	1,374	480	50	166	..	94	119	359	106
September 1965	193, 194	..	6	124	95	5	10	..	5	..	..	9
Do.	STB. 4	..	10½	4,759	1,657	145	184	25	332	947	1,357	112
October 1965	STB. 3, 4, 5	5·20	134	4,435	2,197	174	160	30	174	359	1,133	208
November 1965	Do.	10·20	67½	3,018	1,235	78	550	5	70	70	710	291
December 1965	IB. 194	5·10	9	362	..	..	..	..	..	..	..	..
Do.	STB. 4	10·15	1½	147	..	..	..	..	..	..	..	..
January 1966	IB. 194	5·10	84	3,912	1,410	510	642	..	312	..	978	..
Do.	STB. 4	10·15	90	4,474	1,611	671	739	..	358	..	1,095	..
February 1966	Do.	10·15	105	2,766	1,023	725	354	..	..	111	553	..
March 1966	Do.	5·18	80	2,954	768	148	224	..	266	89	1,459	..
April 1966	I.B. 193	10·25	94	512	..	..	207	..	300	5	..	..
May 1966	I.B. 194	5·25	39	265	..	..	111	..	154	..	..	—
June 1966	Do.	5·15	52	413	..	..	178	..	315	..	—	—

LOCATION OF FISHING GROUNDS IN THE INSHORE AREA OF THE COROMANDEL COAST OF SOUTH ARCOT DISTRICT IN 1963-66.

BY

P. I. CHACKO AND M. V. NATARAJAN.

The inshore fishing station at Cuddalore commenced survey of the inshore stretch of the Bay of Bengal between Pennar river-mouth in the north and Coleroon river-mouth in the South up to the 20th fathom contour, covering a total area of about 500 sq. miles, from 1963. During the period 1963–66, about 100 square miles have been surveyed by operating trawlnets, bottom set nets and drift nets, from three numbers of mechanised boats of the following types:—

1. One 30 feet boat fitted with 24·5 hp. Rustona ir-cooled engine.

2. One 30 feet boat fitted with 37 hp. Ruston air-cooled engine.

3. One 32 feet boat fitted with 50 hp. Torpedo engine.

Details of fishing operations are given below:—

Net used.	*Number of fishing days.*	*Area surveyed in square miles.*	*Quantity of fish caught in Kg.*
(1)	(2)	(3)	(4)
1963–64			
1 Trawl net	51	44	4 480
2 Bottom set net ..	143	34	7,649
3 Drift net	21	24	1,042
1964–65			
1 Trawl net	79	63	15,409
2 Bottom set net ..	41	25	2,772
3 Drift net	66	43	4,925
1965–66			
1 Trawl net	28	51	1,311
2 Bottom set ..	32	26	1,520

The following are the particulars of seven fishing grounds located during the period;—

(1) Trawl ground—Lat 10 degree 39 min. 10 degree 42 min. North and Long 70 degree 46 min.—79 degree 49 min. east. Depth—4 to 11 fathoms. Nature of bottom—clayey. Catch per trawl—65 to 120 kg. Predominant varieties of fish—Silver-bellies, perches and goat-fishes.
Season—April to August.

(2) Trawl ground—Lat. 11 degree 36 min. 11 degree 38 min. north and long 79 degree 49 min. east.

Depth—3 to 5 fathoms.

Bottom—Clay.

Catch per trawl—35 to 65 kg.

Predominent catches—Silver bellies, rays and soles.
Season—throughout the year.

(3) Trawl ground—Lat 11 degree 27 min. 11 degree 30 min. north and long 79 degree 49 min. 79 degree 52 min. east.

Depth—5 to 17 fathoms.
Bottom—Soft clay.
Catch per trawl—75 to 140 kg.
Predominant catches—silver bellies, ribbon fishes, perches and prawns.
Season—June to August and October to December.

(4) Bottom set-net ground—Lat. 11 degree 4 min. 11 degree 43 min. north and 79 degree 49 min. 79 degree 22 min. east.

Depth—6 to 13 fathoms.
Bottom—Muddy with one rocky patch.
Catch per day—75 to 120 kg.

Predominant catches—perches, Small sharks and barracuda.
Season—throughout the year.

(5) Bottom set-net ground—Lat 11 degree 36 min. 11 degree 38 min. north and long 79 degree 49 min.—79 degree 52 min. east.

Depth—8 to 16 fathoms.
Bottom—Rocky.
Catch per day—100 to 140 kg.

Predominant catches—Small sharks, Cat-fishes, Small tuna, Seer and Horse mackerels.

Season—March to August.

(6) Drift net area—Lat 11 degree 41 min. 11 degree 43 min. north and long 79 degree 50 min. 79 degree 52 min. east.

Depth—9 to 12 fathoms.
Catch per day—60 to 90 kg.

Predominant catches—Small sharks, barracuda, seor and horse-mackerels.
Season—Throughout the year except in October-December.

(7) Drift net area—Lat 11 degree 64 min. 11 degree 69 min. north and long 79 degree 63 min. 79 degree 55 min. east

Depth—14 to 19 fathoms.
Catch per day—60 to 125 kg.

Predominant catches—Small and big sharks, barracuda, small tuna and horse-mackerels.

Season—Throughout the year except October–December.

The demonstrations carried out by the Station have attracted a number of owners of mechanised boats to base their operations at Cuddalore especially for trawling. Prawn catches have become significant in this area and processors from Madras and Cochin are purchasing prawns for export to U.S.A. and other foreign countries. A fishing harbour has been established by the State Fisheries Department and it is being expanded to provide berthing facilities for boats up to 7 feet draft. An ice plant and cold storage and a Fishermen's Training Centre have also been established in the harbour. Thus there are prospects for a comprehensive fisheries project at Cuddalore.

SURVEY OF FISHING GROUNDS IN THE PALK BAY AND NORTHERN SECTOR OF THE GULF MANNAR OFF RAMESWARAM, PAMBAN AND MANDAPAM.

BY

P. I. CHACKO AND A. ABDUL RAHIM.

With the introduction of mechanised fishing boats by the Madras State Fisheries Department, a Survey Station is located in Rameswarm to survey the fishing grounds in the Palk Bay and northern sector of the Gulf of Mannar and to demonstrate to the fishermen the method of exploitation of these new areas. A total area of 1,250 square miles, extending from Valinokkam Point to Dhanushkodi in the Gulf of Mannar side and from Devipattanam to Katchatthivu in the Palk Bay is programmed for the survey work. Of this, 300 square miles have been surveyed and the results achieved from April 1962 to March 1966 are reviewed below.

The fishing fleet consisted of one 25 feet, two 30 feet and one 32 feet mechanised boats and one local canoe motorised with a 7·5 hp Lister engine. The particulars of the crafts are given below:—

	IFS. I. (1)	*IFS. II.* (2)	*IFS. III.* (3)	*IFS. IV.* (4)	*Mechanised chance.* (5)
1 Length, Feet ..	30′	30′	25′	32′	29′
Draft. Feet ..	3·2	3·2	2	3·6	1·2
2 Net Tonnage ..	3	3	1	4	1
3 Year Built ..	1960–61	1960–61	1961–62	1963–64	1962
4 Material of hull	Wood	Wood	Wood	Wood	Wood
5 Marine Engine	Bukh	Bukg	Daiya	Perkings.	Lister.
2 HP. ..	30 BHP.	30 CHP.	11 HP.	36 HP.	7·5 HP.

The gears used were two-seam shrimp trawl and four-seam balloon trawls (55 to 75 feet), bottom-set nets of 3–14 inches stretched mesh and trolling lines with 8 and 9 number Mustard hooks. The details are given below:—

(1) *Trawl nets.*

Wing Trawl net.—Two seam shrimp trawl net.
Four seam balloon trawl net.

Head rope—55 feet to 72 feet.

Twine used—Nylon twine 200D×6×3, 200D×8×3, and 200D×10×3.

Head rope—Manilla—Diameter ¾ inch.
Kuralon—Diameter ½ inch.

Floats—Aluminium floats, 6 inches diameter.

Weights—Barrel shaped lead weights each weighing 225 grams.

Otter boards—4½ feet ×2¼ feet—35 to 40 kg.

Mesh sizes—6, 4, 3, 2 and 1 inches. (Stretched).

(2) *Bottom set nets.*

Nets in each unit—12.

Length of the Webbing—50 fathoms.

Height of the webbing—3 to 3½ fathoms.

Felling given—50 per cent.

Twine used—D 200×6×3 ;
D 200×8×3 ;
D 200×10×3 ;
D 200×12×3 ;
and 200×15×3.

Mesh sizes (Stretched), inches—3, 4, 6, 7, 8, 12 and 14.

Breaking strength—Ranging from 26·5 to 60 kg.

Head rope—Coir rope-Diameter ¾ inch, Kuralon rope-Diameter ½ inch.

Ground rope—Coir rope—Diameter one inch.
Kuralon rope—Diameter ½ inch.

Floats used—Aluminium floats—6 inches diameter.
Glass floats—5 inches diameter.
Thermocole floats—6 inches diameter.

Buoyancy—Ranging from 500 to 1000 gms.

Stone Weights—Cement blocks of 130 and 160 m.m. diameters weighing 2 and 2·5 kg.

Blocks—Cement block weighing 70 lb. each.

Flag buoys—Bamboo tied with floats and sinkers with 20 fathom rope when operating in the Palk Bay and 40 to 50 fathom rope when operating in the Gulf of Mannar.

Trolling Lines.

Length—120 to 140 fathoms.

Size—Monofilaments of diameter 3 to 4 m.m.

Hooks used—Mustard Nos. 8 and 9.

The survey data obtained with trawl nets are given in Statements I, II, III and IV. The catch-effort averaged 21 to 367 kg. per hour for the various squares. It is seen that Silver bellies (*Leiognathus spp.*) contribute to the bulk of the catches, being 76 to 94 per cent of the total landings, as shown below :—

Year.	*Total landings.*	*Silver bellies.*	*Percentage of silver bellies to total landings.*
(1)	(2) KG.	(3) KG.	(4)
1961–62	98,857	85,195	76
1962–63	3,24,687	3,01,939	93
1963–64	3,44,453	3,18,298	92
1964–65	2,13,106	2,00,457	94
1965–66	1,45,161	1,36,223	84

The Palk Bay is found to be best-suited for trawling, as the bottom is clayey without any coral or rocky patches beyond six fathom line. The main period for trawling in the Bay is after the north-east monsoon from February to October, though trawling is possible during the intermittent calm spells during the monsoon.

Bottom set-nets are operated throughout the year in the Palk Bay and during the north-east monsoon in the Gulf of Mannar. The monthly details of operations are given in Statements V, VI, VII and VIII. Catch-effort vary from 2 to 8 kg. per hour in the different squares. Nets with 6 to 7 inches mesh obtained maximum catches and are better in six fathoms contour, where the bed is rocky with over-growth of weeds. A special feature is that the leather-jacket (*Chorinemus*) contributes to the bulk of the catches, the maximum being even 80 per cent (vide statement IX). These Oceanic fishes migrate from the Gulf of Mannar to the Palk Bay and *vice versa* through the Adams Bridge and thereby get gilled in the bottom-set nets. Jew fishes (*Sciaena spp.*) also contribute to fairly good catches with these nets.

Trolling has been done in the Gulf of Mannar in an area of about 50 square miles. Fishes obtained are seer, leather jackets, horse-mackerels and jew fishes. The salient features of operating troll lines in March 1966 are as follows:—

Hours of operation—96.

Total landings, kg.—629.

Catch per unit effort, kg./hour—5·5—8·0.

The results so far obtained are encouraging. Trawling was unknown to the fishermen of the area prior to the commencement of the survey and demonstration work. But at present there are about 120 mechanised boats conducting trawling in the area. With further survey and with the establishment of the Indo-Norweign Project at Mandapam, the fishing industry in this part of Madras State is bound to develop considerably along modern lines.

STATEMENT I

Inshore Fishing Survey Station, Rameswaram—Trawl net landings for 1962-63.

Month.	*Square.* 9–79–E–3 (a)	(b	(c)	*Square.* 9–79–E–4 (a)	(b)	(c)	*Square.* 9–79–E2 (a)	(b)	(c)	*Square.* 9–79–C–6 (a)	(b)	(c)	*Square.* 9–79–F–4 (a)	(b)	(c)	*Square.* 9–79–F–5 (a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)			(6)			(7)	
April 1962	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May 1962	81·30	12,522	54	95·5	15,364	160	..	..	..	..	..	..	..	..	..	..	..	..
June 1962	51·25	7,645	150	246·75	43,105	175	..	..	..	..	..	..	..	..	..	..	..	..
July 1962	17·25	2,196	129	247·75	38,510	155	..	..	..	..	..	..	..	..	..	..	..	..
August 1962	19·75	3,481	174	191·25	26,207	137	..	..	..	..	..	..	..	..	..	..	..	..
September 1962	64·75	9,128	140	146·25	20,760	142	..	..	..	..	..	..	..	..	..	..	..	..
October 1962	61·00	8,670	142	84·5	12,071	142	..		..	..	..	..	..	..	..	..	..	..
November 1962	7·25	278	39	92·25	5,675	61	..	..	..	..	..	..	..	..	..	..	..	..
December 1962	106·25	8,598	83	..	..	..	6	97	16	..	..	..	..	..	..	..	..	..
January 1963	..	..	..	126–75	11,296	88	..	..	..	..	..	..	..	..	..	..	..	..
February 1963	54·0	3,908	72	255·25	23,703	92	..	..	..	..	..	..	..	..	..	..	..	..
March 1963	..	..	..	324·25	25,294	78	10	930	93	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours.*
(b) *Total landings, kg.*
(c) *Catch per unit effort kg./hour.*

STATEMENT II.

Inshore Fishing Survey Station, Rameswaram—Trawl net landings for the year 1963–64.

Month.	Square 9—7—E—4			Square 9—7—79—E—5			Square 9—79—C—6			Square 9—79—E—3			Square 9—79—E—2			Square 9—79—F—3		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)			(6)			(7)	
April 1963	161·75	17·576	109	..	..	..	..	..	..	26·5	2,259	85	34·75	2,895	8	..	..	..
May 1963	..	..	..	..	..	..	..	..	..	22·0	1,707	78	15·0	1,490	99	..	..	..
June 1963	202·75	42,482	209	122	18,794	154	4	42	10	17·75	3,596	202	9·5	505	57	..	..	..
July 1963	198·0	45,911	232	112	22,712	203	..	..	..	9.75	958	9	..	..	..	..	..	..
August 1963	94·30	18,493	199	82	12,437	152	..	..	..	36·5	9,183	251	..	..	..	..	..	..
September 1963	126·0	24,862	197	112	21,921	195	..	..	..	..	..	..	..	..	..	7·25	1,133	54
October 1963	18·5	2,665	149	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
November 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
December 1963	40	2,872	72	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
January 1964	68	7,561	111	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February 1964	83	11,712	134	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March 1964	126	19,114	152	..	..	..	..	..		..	..	..	14·5	2,020	200	35·5	5,664	324

(a) *Total fishing hours.*

(b) *Total landings kg.*

(c) *Catch per unit effort, kg./hour.*

Month.	Square 9—79—C—1			Square 9—79—C—11			Square 9—79—B—8			Square 9—79—C—2			Square 9—79—B—4			Square 9—79—E—6		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
		(8)			(9)			(10)			(11)			(12)			(13)	
April 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
June 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
July 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
August 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
September 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
October 1963	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0·36	9	20
November 1963	..	..	..	36·5	376	10	..	..	..	..	..	..	..	..	..	..	..	..
December 1963	..	..	..	3	1·5	0·5	15	1,094	72	..	..	..	..	..	..	..	..	..
January 1964	2.5	20	8	..	..	..	..	..	..	7.5	322	43	..	..	..	..	..	..
February 1964	..	..	..	..	..	..	..	..	..	..	..	..	22	371	17	..	..	..
March 1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours.*

(b) *Total landings. kg.*

(c) *Catch per unit effort, kg./hour.*

STATEMENT III.

Inshore Fishing Survey Station, Rameswaram—Trawl net landings for the year 1964–65.

Month.	Square 9—79—E—5			Square 9—79—E—6			Square 9—79—C—6			Square 9—79—E—4		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)	
April 1964	85·5	7,729	90	13·25	2,017	155	6	521	87	6·5	1,518	232
May 1964	223	31,879	143	..	..	..	..	..	..	..	..	..
June 1964	226	38,104	120	7·0	422	60	1·5	563	376	..	..	..
July 1964	173·5	34,851	201	..	..	..	..	..	..	..	..	..
August 1964	118·5	20,609	173	..	..	..	..	..	..	..	..	..
September 1964	41	4,352	106	..	..	..	..	..	..	..	..	..
October 1964	..	..	..	..	..	..	..	..	..	..	..	..
November 1964	..	..	..	..	..	..	..	..	..	..	..	..
December 1964	..	..	..	..	..	..	..	..	..	..	..	..
January 1965	..	..	..	..	..	..	..	..	..	..	..	..
February 1965	..	..	..	..	..	..	..	..	..	..	..	..
March 1965	..	..	..	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours.*

(b) *Total landing kg.*

(c) *Catch per unit effort, kg./hour.*

Month.	Square 9—79—E—2			Square 9—79—F—5			Square 9—79—F—3			Square 9—79—E—4			Square 9—79—E—4		
	(a)	(b) (6)	(c)	(a)	(b) (7)	(c)	(a)	(b) (8)	(c)	(a)	(b) (9)	(c)	(a)	(b) (10)	(c)
April 1964	3·00	667	222	..	..	..	..	..	..	..	..	..	..	..	..
May 1964	21·75	3,304	153	..	..	..	..	..	..	..	..	..	..	..	..
June 1964	..	..	..	37·5	8,779	234	..	..	..	..	..	..	..	..	..
July 1964	..	..	..	28·5	6,092	213	7	1,755	250	..	..	..	..	..	..
August 1964	..	..	..	107·5	23,329	217	..	..	..	..	..	..	..	..	..
September 1964	..	..	..	30·0	3,389	112	..	..	..	..	..	..	..	..	..
October 1964	..	..	..	42·5	9,339	219	..	..	..	53	9,414	177	..	..	..
November 1964	..	..	..	..	..	..	..	..	..	..	..	..	28·5	3,920	137
December 1964	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
January 1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
February 1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
March 1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours.*

(b) *Total landing, kg.*

(c) *Catch per unit effort, kg./hour.*

STATEMENT IV.

Inshore Fishing Survey Station, Rameswaram—Trawl net landings for the year 1965–66.

Month.	Square 7—9—E—4			Square 9—79—C—7			Square 9—79—F—6			Square 9—79—D—5			Square 9—79—F—4		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)			(6)	
April 1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
May 1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
June 1965	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
July 1965	81·00	13,885	171	12·00	1,896	158	..	..	..	..	..	..	..	..	..
August 1965	97·00	19,534	201	21·00	3,925	187	..	..	..	..	..	..	..	..	..
September 1965	83·75	21,664	261	19·5	3,375	173	..	..	..	..	..	..	..	..	..
October 1965	66·00	16,970	260	12·5	2,442	190	4	1,373	343	..	..	..	..	..	..
November 1965	66·00	13,299	201	10·5	1,510	144	6·75	891	132	9·25	198	21	3	1,037	346
December 1965	12·50	6,012	500	..	..	..	..	..	..	..	..	..	..	..	..
January 1966	37·00	8,588	232	..	..	..	..	..	..	..	..	..	..	..	..
February 1966	55·75	6,090	110	2·5	79	31	43	4,334	101	..	..	..	..	..	..
March 1966	49·5	7,015	164	13·0	1,732	133	30·6	4,200	140	..	..	..	..	..	..

(a) *Total fishing hours.*

(b) *Total landings, kg.*

(c) *Catch per unit effort, kg./hour.*

STATEMENT V.

Inshore Fishing Station, Rameswaram—Bottom set net landings, 1962-63.

Month.	Square 9-79-E-4.			Square 9-79-E-5.			Square 9-79-D-6.			Square 9-79-D-5.			Square 9-79-B-3.			Square 9-79-E-6.		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)			(6)			(7)	
April 1962	..	..	..	..	..	..	410	3,574	9	..	..	..	..	..	..	..	..	..
May 1962	..	..	..	270	324	1	500	2,556	5·5	..	..	..	..	..	..	..	..	..
June 1962	..	..	..	500	3,481	14	210	1,016	5·0	..	..	..	..	..	..	..	..	..
July 1962	..	..	..	460	3,290	7	..	..	..	50	256	5	..	..	..	210	1,871	6
August 1962	..	..	..	470	1,950	4	..	..	..	..	..	..	..	..	..	140	367	2
September 1962	100	208	2	240	1,600	7	..	..	..	170	2,495	12	..	..	..	..	..	..
October 1962	..	..	..	270	2,373	9	160	384	4	230	684	4	..	..	..	..	..	..
November 1962	..	..	..	240	457	2	240	1,178	5	..	..	..	..	..	..	..	..	..
December 1962	40	157	4	370	987	3	..	..	..	..	..	..	..	..	..	..	..	..
January 1963	460	1,840	4	..	..	..	..	..	..	..	..	..	260	772	3	..	..	..
February 1963	..	..	..	230	937	4	240	1,415	6	..	..	..	..	..	..	..	..	..
March 1963	24	62	3	24	156	6	..	..	..	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours.*

(b) *Total landings, kg.*

(c) *Catch per unit effort, kg./hour.*

STATEMENT VI.

Inshore Fishing Station, Rameswaram—Bottom set net landings for 1963–64.

Month.	Square 9—79—E—4.			Square 9—79—E—5.			Square 9—79—D—5.			Square 9—79—D—6.			Square 9—78—B—11.			Square 9—78—B-12.			Square 9—79—B—3.		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)			(6)			(7)			(8)	
April 1963	60	232	4	552	2,440	6	24	37	1·5	..	..	..	..	..	..	..	..	..	..	..	..
May 1963	84	246	3	552	1,364	2·3	225	793	3	72	266	3·7	..	..	..	..	..	..	..	..	..
June 1963	72	111	1·5	408	1,449	3·5	348	935	3	48	121	2·5	..	..	..	..	..	..	..	..	..
July 1963	..	..	..	568	1,671	2·7	132	302	2·5	108	394	3·0	..	..	..	..	..	..	..	..	..
August 1963	96	176	2	276	608	2·0	276	640	2·0	72	182	2·4	..	..	..	..	..	..	..	..	..
September 1963	360	2,117	6	480	1,910	4·0	48	160	3·5	36	42	1·2	..	..	..	..	..	..	..	..	..
October 1963	348	1 726	5	84	261	3·0	24	79	3·0	72	307	4·0	72	584	8	..	..	..	..	..	..
November 1963	384	1,242	3	108	227	2·0	24	49	2·0	..	..	..	96	770	8	72	340	5	..	..	..
December 1963	240	718	3	..	..	..	..	..	..	144	2,530	1·7	..	..	..	36	303	9	..	..	..
January 1964	96	228	2	168	765	4·0	..	..	..	48	259	5·0	..	..	..	60	191	3	144	..	5
February 1964	132	886	6·5	456	3,637	8·0	..	..	..	..	..	..	..	..	..	12	32	2	..	..	..
March 1964	156	926	6·0	672	3,514	5·0	12	22	..	..	..	..	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours.*

(b) *Total landing, kg.*

(c) *Catch per unit effort, kg./hour.*

STATEMENT VII.

Inshore Fishing Station, Rameswaram—Bottom set net landings 1964–65.

Month.	Square 9—79—E—5.			Square 9—79—E—4.			Square 9—79—D—6.			Square 9—79—D—5.		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)	
April 1964	844	5,122	5	60	280	4	..	..	..	..	..	..
May 1964	828	3,001	3	24	28	1	36	108	3	36	94	2
June 1964	576	2,384	4	156	709	4	12	56	5	156	306	2
July 1964	264	555	2	240	366	1	..	..	..	444	1,595	3
August 1964	216	583	2	168	402	2	120	427	3	312	682	2
September 1964	120	152	1	288	491	1	105	222	2	168	248	1
October 1964	192	334	1	108	213	1	36	65	1	420	1,494	3
November 1964	72	89	1	132	270	2	24	64	2	324	442	1
December 1964	..	..	..	..	..	..	..	..	..	456	1,034	2
January 1965	..	..	..	..	..	..	..	..	..	..	..	..
February 1965	..	..	..	..	..	..	..	..	..	..	..	..
March 1965	..	..	..	24	101	4	..	..	..	252	1,081	4

(a) *Total fishing hours.*

(b) *Total landings, kg.*

(c) *Catch per unit effort, kg./hour.*

STATEMENT VIII.

Bottom set net operations during 1965–66.

Month.	Square 9—79—E—4.			Square 9—79—E—5.			Square 9—79—D—6.			Square 9—79—D—5.			Square 9—78—B—11.			Square 9—78—B—12.			Square 9—79—B—3.		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
(1)		(2)			(3)			(4)			(5)			(6)			(7)			(8)	
April 1965	348	900	4	312	1,281	4	..	..	..	12	49	4	..	..	–	24	97	4	..	..	..
May 1965	372	1201	3	288	968	4	..	..	..	144	496	4	..	..	–	24	103	5	..	..	..
June 1965	168	443	3	348	1,416	4	..	..	..	408	1,282	3	..	..	..	..	..	..	..	..	..
July 1965	60	135	2	60	150	3	..	..	..	780	2,229	3	..	..	..	..	..	..	..	..	..
August 1965	156	138	1	36	11	..	84	118	1	492	402	1	..	..	..	12	27	2	..	..	..
September 1965	228	367	2	156	332	2	..	..	..	264	318	1	..	..	..	..	..	..	..	..	..
October 1965	180	219	1	38	116	3	48	70	2	300	276	1	..	..	..	24	21	1	..	..	..
November 1965	84	146	2	384	1,130	3	..	..	..	84	106	1	..	..	..	..	..	..	..	..	..
December 1965	120	225	2	12	19	2	..	..	..	261	609	3	..	..	..	..	..	..	..	..	..
January 1966	84	93	1	12	34	3	..	..	..	12	2	..	..	..	..	228	508	2	264	535	..
February 1966	36	113	..	..	..	..	..	..	..	..	..	..	36	71	2	24	74	3	..	..	..
March 1966	234	927	4	108	302	3	..	..	..	156	532	3	..	..	..	..	..	..	..	..	..

(a) *Total fishing hours*

(b) *Total landing, kg.*

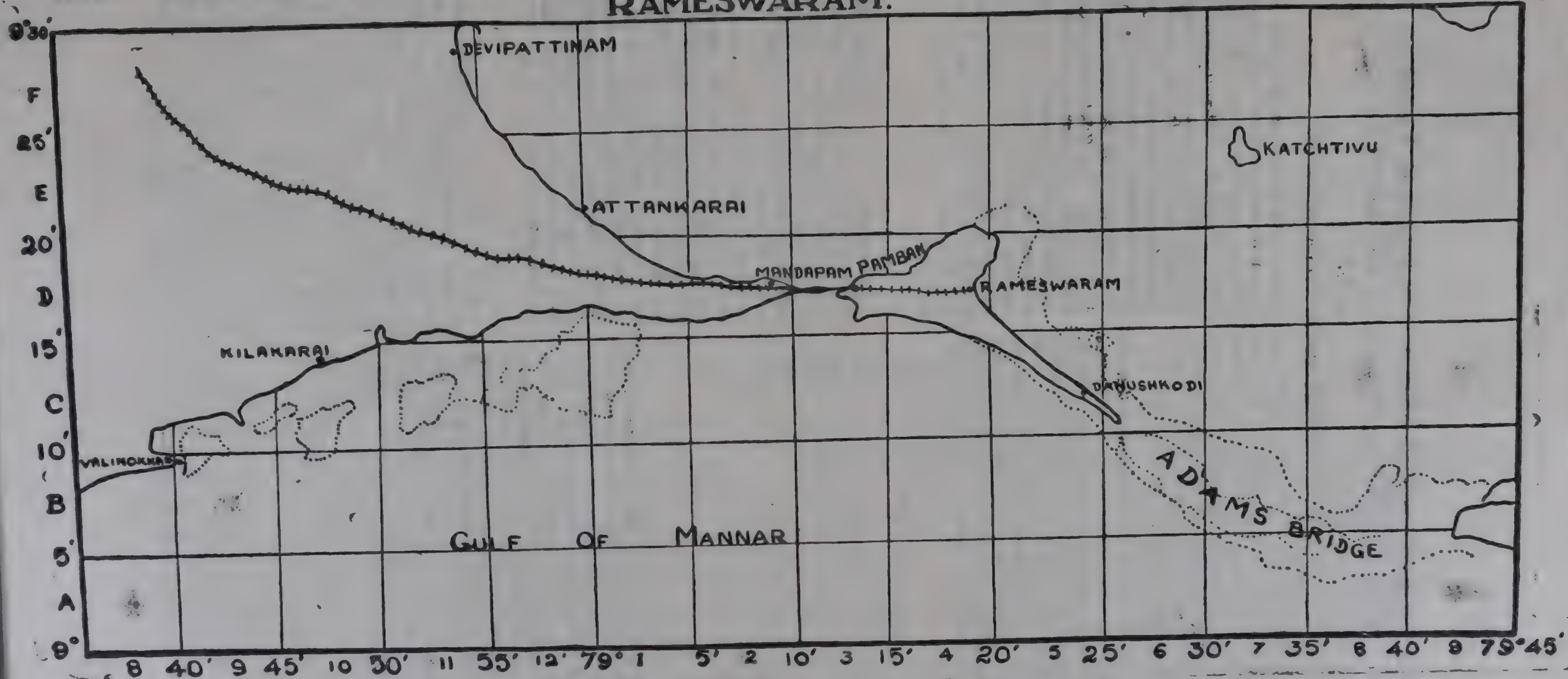
(c) *Catch per unit effort, kg./hour.*

STATEMENT IX.

Landings of Chorinemus species in the Palk Bay area from bottom set gill net fishing operations—Survey conducted by the Inshore Fishing Station Boats.

	1962.			1963.			1964.			1965.		
	Landings of Chorinemus.	*Total landings.*	*Per cent.*	*Landings of Chorinemus.*	*Total landings.*	*Per cent.*	*Landings of Chorinemus.*	*Total landings.*	*Per cent.*	*Landings of Chorinemus.*	*Total landings.*	*Per cent.*
	KG.	KG.		KG.	KG.		KG.	KG.		KG.	KG.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
January	194	4,432	4·4	45	2,137	2·05	92·5	2,178	4·3	..	..	..
February	214	2,139	10·0	510	2,352	21·60	753·5	6,077	12·3	199	1,668	11·0
March	2,625	4,428	54·7	508	1,286	28·70	1,943·0	4,462	43·3	1 ,853	3,135	19·4
April	5,372	7,150	74·9	2,586	3,209	80·50	3,386·0	5,403	61·7	1,655	2,867	57.7
May	942	2,425	32·2	1,406	2,619	53·60	1,670·0	3,229	51·7	719	2,494	20·8
June	1,946	3,619	33·8	912	2,763	33·00	1,391·0	3,456	40·0	1,315	3,241	40·8
July	1,862	2,822	41·8	877	5,368	37·00	1,315·0	2,537	51·8	1,626	2,515	41·7
August	125	1,688	7·4	200	1,646	12·20	629·0	2,089	30·2	174	696	25·0
September	99	1,057	9·3	2,301	4,029	57·10	393·0	1,642	23·9	294	1,017	28·9
October	1,644	3,100	53·0	1,667	3,897	32·50	433·50	2,223	19·4	159	708	22·5
November	149	2,181	6·2	258	3,516	7·40	520·0	1,785	29·1	246	1,382	10·7
December	195	1,744	11·2	91	3,550	2·50	20·0	1,065	1·9	117	836	14·0

MAP SHOWING AREA OF OPERATION OF INSHORE FISHING STATION, RAMESWARAM.


DEVIPATTINAM
KATCHTIVU
ATTANKARAI
MANDAPAM
PAMBAN
RAMESWARAM
KILAKARAI
DANUSHKODI
VALINOKKAM
ADAMS BRIDGE
GULF OF MANNAR
9°30'
F
25'
E
20'
D
15'
C
10'
B
5'
A
9°
8
40'
9
45'
10
50'
11
55'
12'
79°
1
5'
2
10'
3
15'
4
20'
5
25'
6
30'
7
35'
8
40'
9
79°45'

ECONOMICS OF OPERATION OF MOTOR FISHING VESSELS IN THE COASTAL WATERS OF MADRAS STATE

BY

P. L. CHACKO AND S. THYAGARAJAN

The programme of introduction of motor boats for exploiting the coastal waters of Madras State, initiated in 1957, has become popular among the fishermen. About 500 motor boats are now being operated by the fishermen. With a view to assess the economics of operation of these boats, the details of the working of ten boats for twelve months were studied and the results are given below.

Example I.—A motor vessel 30 feet in length and fitted with 30 horse power Yanmar engine is operated off Madras by the fishermen's Training Centre for training its candidates in modern methods of fishing. The net employed is 60 feet non-overhang trawl net made of nylon twine. The crew consists of a driver and a lascar and six trainees. During the twelve months, November 1965—October 1966, the boat operated on 106 days, obtaining a total catch of 20,515 kg. of fish of the following composition.—

	Kg.
Sharks and Rays .. .. .. —	1,553
Upenoides	5,969
Silver bellies	6,644
Sardines and anchovies	665
Horse-mackerels .. .. .. —	236
Seer	47
Jew fishes	2,342
Perches	285
Cat fishes	108
Prawns	941
Others	1,725

The catches are handed over to the Fishermen's Co-operative Federation for implementing a pilot scheme for marketing of fish in Madras City under a door-to-door delivery system at a price lower than the prevailing market rates. Consequently, the sale proceeds obtained by the Training Centre is only Rs. 9,075. The total operational cost during the period amounted Rs. 10,018, including Rs. 2,968 towards cost of 4,240 litres of H.S.D. oil, Rs. 600 towards maintenance and repairs to engine and gear, Rs. 5,400 towards wages of crews and labour and Rs. 3,650 towards harbour dues. It has to be noted that the harbour dues levied by the Madras Port Trust for a small fishing boat is rather high. Nevertheless the operation of the boat, though only for training of fishermen and not for commercial purpose, has been on a no-profit no-loss basis and the average catch per day of 8 hours cruise has been 183·54 kg. per day and the catch effort (for 4 hours spent on the fishing ground) is 46 kg. per hour.

Example II.—A 32 feet motor boat fitted with 50 horse-power Torpedo engine is operated off Madras by the Fisheries Departmental Survey Unit for survey and assessment of potential fishing grounds. During the year 1965–66, the vessel was operated on 98 days each of 10 hours cruise of which 5 hours are spent on fishing ground, employing a 57 feet trawl net. The crew consisted of 1 driver, 1 lascar and 4 fishermen. The total catch was 30,778 kg. comprising of 10,169 kg. of silver-bellies, 8,944 kg. of jew fishes, 3,232 kg. of prawns, 2,079 kg. of upenoides and 6,354 of other varieties. In this case also the catches are delivered to the Fishermen's Co-operative Federation for its pilot scheme for house-delivery of fish in Madras City. The sale proceeds obtained by the Survey Centre was Rs. 18,510. The total operational cost was Rs. 14,268, including Rs. 4,802 towards 6,860 litres of H.S.D. oil, Rs. 2,000 towards maintenance and repairs to boat, engine and gear, Rs. 3,816 towards wages and crew and Rs. 3,650 towards harbour dues. In spite of heavy expenditure on harbour dues paid to the Madras Port Trust the receipt has exceeded expenditure by Rs. 4,242. The catch per day has been 303·5 kg. per day and the catch effort 60·6 kg. per hour.

Example III.—A 32 feet vessel fitted with 50 horse power Torpedo engine, operated off Madras by a group of 6 fishermen, along commercial lines, using both trawl and bottom set gill nets, obtained in 1965–66 a total catch of 85 tons in 200 fishing days with an average of 425 kg. per day. The catch effort is 85·0 kg. per hour. The daily catch consisted of about 100 kg. of jew fishes, 75 kg. of upenoides, 125 kg. of silver bellies, 100 kg. of sharks and rays, 50 kg. of prawns and 25 kg. of other varieties. The total sale proceeds during the year by auctioning to fish merchants was Rs. 80,000. The total operational cost was Rs. 52,879 including Rs. 7,840 on H.S.D. oil, Rs. 2,700 on maintenance of boat and gear, Rs. 32,500 on wages of crew, Rs. 500 on harbour dues, Rs. 1,230 on insurance and Rs. 8,100 on payment towards cost of boat and gear, which are obtained from the Fisheries Department. The net annual profit on the operation of this boat is Rs. 27,121.

Example IV.—Another 32 feet motor vessel, fitted with 50 horse power engine and with a crew of 6 fishermen obtained a total catch of 47 tons of fish for 200 fishing days in 1965–66 by using trawl and gill nets off Madras. The catch effort was 235 kg. per day and 47·00 kg. per hour. The daily catch consisted of 50 kg. of jew fishes, 35 kg. of upenoides, 100 kg. of silver bellies, 20 kg. of prawns and 30 kg. of other varieties. The total sale proceeds by auctioning to fish merchants was Rs. 67,000. The expenditure for the year was Rs. 40,220 including Rs. 7,840 on H.S.D. oil, Rs. 2,650 on maintenance and repairs, Rs. 20,000 on wage of crew, Rs. 400 on harbour dues, Rs. 1,230 on insurance and Rs. 8,100 on payment towards cost of boat and nets which are taken from the Fisheries Department on hire-purchase system. The net annual profit was Rs. 26,700.

Example. V.—A group of seven fishermen operated gill and trawl nets off Madras from a 32 feet motor vessel fitted with 50 horse power engine ; and obtained a total catch of 59 tons in 200 fishing days in 1965–66 and realised a gross return of Rs. 71,000. The daily catch averaged 295 kg., consisting of 75 kg. of jew fishes, 45 kg. of upenoides, 125 kg. of silver-bellies, 25 kg. of prawns and 25 kg. of other species. The catch-effort was 59·0 kg. per hour. The total income by auctioning the catches was Rs. 71,000. The total expenditure during the year was Rs. 42,370 including Rs. 7.840 on cost of fuel, Rs. 2,700 on maintenance and repairs, Rs. 300 on harbour dues, Rs. 22,000 on wages of crew, Rs. 1,230 on insurance and Rs. 8,100 on repayment of cost of boat and gear which were received from the Fisheries Department on hire purchase basis. The net annual profit was Rs. 28,630.

Example VI.—Another group of 6 fishermen of Madras who operated gill and trawl nets from a 32 feet motor vessel fitted with 50 horse-power Torpedo engine obtained 130 tons of fish in 200 fishing days. The daily catch averaged 650 kg. per day, consisting of about 100 kg. of jew fishes, 100 kg. of upenoides, 200 kg. of silver-bellies, 100 kg. of sharks and rays, 100 kg. of prawns and 50 kg. of other varieties. The catch-effort has been 130 kg. per hour. The gross sale proceeds amounted Rs. 1,22,000 and the total expenditure was Rs. 69,932–50 comprising of Rs. 7,840 on oil, 2,700 on maintenance of craft and gear, Rs. 49,562–50 on wages of crew, Rs. 500 on port dues, Rs. 1,230 on insurance and Rs. 8,100 towards repayments of cost of boat and nets. The net annual profit was Rs. 52,067–50.

Examples VII.—A 30 feet motor vessel, fitted with 30 horse-power Bukh engine was operated by the Fisheries Departmental Survey Unit in the Palk Bay with Rameswaram as base. Wing trawl net of 55 feet was used. The crew consisted of one driver and four fishermen. A total catch of 182,942 kg. was obtained on 201 fishing days in 1965–66. The landings consisted mostly of silver-bellies (92 per cent), rays (5 per cent), cat-fishes (2 per cent) and other varieties. The daily catch averaged 901 kg. and the catch effort was 182 kg. per hour. The catches were sold to the Ramanathapuram District Fishermen's Co-operatives Federation ; and the annual revenue was Rs. 16,640. The annual expenditure was Rs. 11,074 thus obtaining a net profit of Rs. 5,566.

Example VIII.—A similar motor vessel (30 feet length and 30 horse-power Bukh engine) was also operated in the Palk Bay by the Rameswaram survey unit, using 58 feet wing trawl nets. The total catch for 133 fishing days in 1965–66 was 154,572 kg. and by selling this to the Ramanathapuram District Fisherman's Co-operatives Federation a return of Rs. 14,120 was obtained. The catch comprised of silver- bellies (90 per cent), rays (6 per cent), cat fishes (2 per cent) and other varieties (2 per cent). The total operational cost was Rs. 8,584 giving a net annual profit of Rs. 5,536. The catch averaged 1,162 kg. per day and 232 kg. per hour.

Example IX.—A group of 5 fishermen operated a 30 feet motor vessel (30 horse-power yanmar engine) from April 1965 to March 1966, with 35 feet trawl and obtained a remarkable catch of 500 tons in 240 fishing days and realised Rs. 45,000 by sale to fish-merchants. The annual expenditure was Rs. 24,886 including cost of fuel, wages of crews (Rs. 6,000), insurance and dues towards cost of boat and gear. The net profit was Rs. 20,114. The daily catch averaged 2,083 kg. Silver bellies contributed to 90 per cent of the landings. The catch-effort was 416 kg. per hour.

Example X.—A 28 feet clinker-built motor vessel, fitted with 20 horse-power Marna engine was operated off Mandapam from April 1965 to March 1966 by a group of 4 fishermen, using two seam non-overhang trawl nets (13fathoms). The total catch was 84,546 kg. per 126 fishing days and consisted mostly (90 per cent) of silver bellies. The catch per day averaged 671 kg. and the catahceffort was 134 kg. per hour. The total sale-proceeds was Rs. 5963·48 and the expenditure including running and maintenance cost, insurance and hire charges for boat and net, was Rs. 5,785–23 paise leaving a very small margin of Rs. 178·25 as profit.

Conclusions.

An analytical study of the data shows interesting results. The catch per day of 8–10 hours cruise from port to fishing ground and back and 4 to 5 hours of actual fishing varied from 184 to 2,082 kg., the maximum being in the Rameswaram area where silver bellies contribute to the bulk of the catches. Correspondingly the catch effort also varied from 46·0 to 416·0 kg. per hour. The total annual income for a boat ranged from Rs. 5,964 to Rs. 1.22,000. The boats operated by groups of fishermen in Madras area obtained better returns due to the good quality of the catches and better price. The boats of Rameswaram and Mandapam area, though getting larger quality of fish did not fetch more sale proceeds as the bulk of the catches was silver bellies of low market value. The net profit in a year for a boat varied from Rs. 178·25 to Rs. 5,566 and the daily income per boat ranged from Rs. 47 to Rs. 400. The gross daily earning per fisherman working in the motor boats was from Rs. 10·68 to Rs. 101·66 and the net daily income from Rs. 6·36 to Rs. 84·66. The sea fishermen of Madras State have thus realised the advantage of owning and operating motor boats. With more training and experience the fishermen will be able to use motor boats on a larger scale and thereby increase fish production as well as improve their own economic condition.

FISH PRODUCTION IN TWO TEMPLE TANKS IN MADURA CITY AND AN ECOLOGICAL STUDY THEREOF

BY

A. SRINIVASAN, Fresh Water Biological Station, Bhavanisagar P.O., Madras.

Use of religious institutional waters for fish culture has been advocated by Chacko (1948). Since most of the temple tanks are not made use of for any other purpose, and since they accumulate rich organic matter causing nuisance smells by algal blooms, they pose problems of public health. Stocking these waters with fish is the best way of removing the organic growth and getting a valuable crop of protein rich fish. Thus, what is a public health problem, is turned into a solution of the problem of protein malnutrition. In pursuance of raising fish from all water sources available, many temple tanks are taken over and stocked with fish by Madras Government.

Material and methods.

Water samples were collected in the mornings and analysed on the spot by standard methods. Soil samples were collected, air dried and analysed according to Spurway (1946). Plankton collections were made in the manner described by Krishnamoorthy et al (1957).

Description of the tanks.

The Mariamman Teppam in Madurai is in the heart of that city and is used for the "float festival" of the famous Meenakshi Temple. It is an old tank, constructed three centuries back. It is square in shape and has steining all round, giving a vertical wall with steps at intervals. There is a "mantap" in the centre. The sides of the tank measure 270 m (900 feet) and the "mantap" which is also square has sides 60 m (200 feet). The effective water spread is about 17 acres (about 6·9 ha.) The maximum depth of the tank is roughly 3·6 m (12 feet) but in summer it goes down to 1·5 m (5 feet) and some times even dries up. The tank is regularly used for bathing and washing by local populace but during festival periods very large number of pilgrims use and pollute the water. River water from Vaigai river and storm water from rains supply the water to the tank. Since the inlet channel is polluted by town sewage, the tank receives heavy dose of pollution. There is no overflow or outlet to drain the water.

Tirumakulam, is a 1·6 ha (4 acre) tank belonging to Kallazhagar Temple but differs from Mariamman Teppam in not having stone walls all round. The side slope gently towards the centre. The water is mainly used for bathing and washing by men and some times by cattle also. This is purely rain fed but usually does not dry up.

Hydrological conditions.

Physico-chemical conditions of the water of Mariamman Teppam were studied on five occasions between 1956 and 1960 and on three occasions Tirumakulam water was studied. The temperature reached a high level of 34·4 degree centigrade in September 1959 in Teppakulam. The lowest noted was 28·3 degree centigrade. The transparency was low, viz., 60·0 to 15·0 cms. due to plankton blooms. Free carbon-dioxide was invariably absent and fairly large quantities of carbonates were found. A very high bicarbonate content also characterized this water. The chlorinity was very high for a fresh water tank. Hardness was above medium. Silicates were present in moderate quantities but phosphates were not detected more than in traces. Dissolved oxygen content was not high, but usually adequate. Nitrate was detected once in large quantities 8·0 p.p.m. The pH was always alkaline and mostly above 9·0· Though this high pH is indicative of great photosynthetic activity, this is not reflected in the oxygen content of the water which is low perhaps due to chemical demand.

The Tirumakulam tank, in the same City just three miles away differs from the Teppakulam. In this tank free carbondioxide was present indicating that photosynthetic activities were not high. Carbonate, where present was not as high as in Teppakulam and similarly was bicarbonate. The Chloride content was also far less than that of the other tank.

However the nutrients, silicates and phosphates were present in larger quantities. The pH was on the alkaline side, though never so high as in Teppakulam. Oxygen deficit was noted in the bottom layer. High alkalinity, as seen from the bicarbonate and pH are conducive to increased production (Waters 1957).

Plankton.

The volume of the plankton in Teppakulam was 0·1 cc/10L in June 1956 when it was composed of 70 per cent *Cyanophyceae* and 30 per cent *Chlorophyceae* and no zooplankton at all. In July 1960 the *Chlorophyceae* dominated over the *Cyanophyceae*. The diatom *Nitzchia* was also present. It could be seen that most of the algae occurring in this tank are forms indicative of pollution (Palmer 1959). This is proved to be correct by the actual fact of drainage of sewage into the tank and by the high chloride content. On the other hand *Tirumakulam* appears to have a slightly richer plankton but composed of mainlyclean water forms. Though the green alga *Scenedesmus*, dominates in number, two diatom species,viz., *Nitzschia Navicula* are present. The red alga *holopedium* as also the desmid *Staurastrum* are present. *Pediastrum* is another green alga present. The plankton differs from the one discribed by Krishnamoorthy et al (1957) or the Mariamman Teppam. The higher plankton content as well as the high zooplankton numbers could be due to the decay of myriads of fish which had died. Menon (Unpubl. 1956) did not find any zooplankton in this tank. Ganapathi et al (1953) and Ganapati (1940) found in Temple tanks mainly a bloom of *Microcystis aeruginosa*. But in the two temple tanks studied by us, this eutrophic indicator alga was absent. Warm calcareous waters moderately rich in nitrogen as these two tanks favour chlorophyceae such as *Scenedesmus* and *Pediastrum*.

Fish production.

In Mariamman Teppakulam fish production has been increasing from 19,813 lb. in 1955–56 (1,166 lb. per acre) to 37,000 lb. in 1959–60 (2,176 lb. per acre). By all standards this production is fairly good. The low yield in 1956–57, is due to very heavy mortality of fishes in 1955 (Krishnamurthy et al 1957). Introduction of *Tilapia mossambica*, while increasing gross production, had adverse effect on *chanos chanos* and the major carps such as *Catla Catla*.

On the other hand though Tirumakulam, has ecological conditions favourable for high fish yield, in actuality it did not yield as good a crop as Teppakulam. This is mainly due to faulty management techniques and not due to adverse ecological conditions. The hypolimnical oxygen deficit is an indication of high productivity of the water. The pysico-chemical conditions were also favourable. These two ecosystems could be utilised to produce a high yield of fish.

References.

Chacko, P. I. 1948	Fish production in religious intitutional waters Jour. Bombay Net. Hist. Soc. XLVII 746—766.
Ganapati, S. V. 1940	The ecology of a temple tank containing a permanent bloom of Microcystis acruginosa *ibid*, XLII, 65—77.
Ganapati, S. V. Chacko, P. I. and Srinivasan, R. 1953.	Hydrobiological conditions of the Ganga dhareswarar Temple Tank, Madras. Jour. Asiatic. Soc. Science, XIX (2), 149–159.
Krishnamuthy, B., Dorairajah, K. A. and Venkatasamy, A. D. 1957.	An investigation of large scale fish mortality in a temple tank in Madurai Proc. Ind Acad. Sci., XLV B, (4), 165–. 175.
Palmar, C. M. 1959	"Algae in water supplies" U.S. P.H.S. Publ. No. 657 1–88 pp.
Spurway. C. M. 1944	"Soil Testing" Michigan State coll., Tech. Bull. 132 pp. 1–38.
Sreenivasan, A. 1962 ..	The ecology and fish production of two polluted fort moat waters in Madras State. Proc. Inst. Soc. Trop. Ecol. (in press).
Waters, Thomas F. 1957 ..	The effect of lime applications on acid bog lakes in Northern Michigan. Trans. Amer. Fish. Soc., 86 (1956), 329.

TABLE I.

Hydrological conditions of two temple tanks in Madras City.

	Mariamman Teppam.					*Tirumakulam.*		
Dates.	*6th June* 1956.	*17th October* 1957.	*27th March* 1959.	*7th September* 1959.	*15th July.* 1960.	*18th November* 1957.		
						Surface.	*Bottom.*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9))
Time (Hours)	8·00	9·15	8·00	8·30	6·30	8·00	8·30	17·00
TemperatureC°	28·3	29·8	28·6	34·4	29·6	28·8	28·0	28·4
Transparency (cms) ..	†	15·0	†	6·0	15·0	7·2	9·5	6·0
Free carbondioxide* ..	Nil.	Nil.	Nil.	Nil.	Nil.	2·2	2·32	Nil.
Carbonate*	72·0	60·0	34·0	40·8	57·0	Nil.	Nil.	30·0
Bicarbonate*	189·1	271·5	216·0	268·4	155·5	112·9	112·9	112·5
Chloride*	360·0	388·0	858·0	3,180·0	334·0	94·0	98·0	50·0
Hardness*	200·0	190·0	†	†	†	†	†	†
Silicates*	†	8·0	†	4·0	6·0	10·0	10·0	4·0
Phosphate *	Traces.	Traces.	Traces.	Nil.	Nil.	0·32	0·40	Nil.
Nitrate*	Nil.	8·0	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Dissolved oxygen mg/l ..	3·0	4·1	2·5	4·4	0·9	2·9	1·4	6·1
pH	9·0	8·7	9·2	9·6	9·5	7·9	7·9	8·2

* in p.p.m.
† Not estimated.

TABLE II.

Soil conditions of the two temple tanks.

Constituents p.p.m.	*Mariamman Teppam.*		*Tirumakulam.*
	7th September 1959.	*15th July 1960.*	*7th September 1959.*
(1)	(2)	(3)	(4)
Ammonia	2·0	2·0	2·0
Nitrate	Nil.	Nil.	Nil.
Phosphate (Reserve) ..	0·5	0·5	0·5
Iron	3·0	3·0	6·0
Chloride	Trace.	150	Nil.
Sulphate	Nil.	Present.	Nil.
Aluminium	Nil.	Nil.	Nil.
Magnesium	6	6	6
Manganese	Nil.	Nil.	Nil.
Calcium	40·0	100·0	40·0
pH (units)	8·0	8·0	8·0

TABLE III.

Fish production in two temple tanks in Madurai City.

Year.	*Mariamman Teppam.*		*Tirumakulam.*	
	Total. lbs.	*lbs. per acre.*	*Total lbs.*	*lbs. per acre.*
(1)	(2)	(3)	(4)	(5)
1961–62	15,469	910	9,385	2,346
1960–61	8,471	498	2,392	598
1959–60	37,000	2,176	2,600	650
1958–59	26,700	1,571	524	131
1957–58	26,000	1,541	774	194
1956–57	1,278	75	..	..
1955–56	19,813	1,166	..	..

TABLE IV.

Plankton occurring in the two Madurai tanks.

	Mariamman Teppam. per L.		*Tirumakulam per L.*	
(1)	(2)		(3)	
Cyanophyceae	*Anabaena*	5,000	....	
	Oscillatoria	11,250	....	
Chlorophyceae	*Scenedesmus*	38,250	*Scenedesmus*	49,500
			Pediastrum	1,750
Diatomae	*Nitzschia*	2,750	*Nitzschia*	2,000
		..	*Navicula*	750
	Desmid	..	*Staurastrum*	750
	Rdalga	..	*Holopedium*	60,000

A NOTE ON THE EFFECT OF SOME TRACE ELEMENTS ON PRIMARY PRODUCTION AND FISH YIELD IN SMALL PONDS

BY

A. SREENIVASAN AND R. SOUNDER RAJ.

The beneficial use of fertilizers in fish ponds is beyond doubt[1]. The inorganic nutrients increase the multiplication of phytoplankton and to some extent of Zooplankton and with compatible species of fish lead to better growth and yield of fish. Since, trace elements like boron, cobalt, zinc and molybdenam play a vital role in plant growth, it was thought desirable to study their effect on productivity. Large cement tanks of size 6 × 3 × 2 m. with a layer of 15 cms. soil at the bottom were used in these experiments.

All cisterns except one were fertilized with a low does of N.P.K. (0—3·5—2·5). Trace elements were applied at the rate of 0·05 P.P.M. of the element, based on water volume. The hydrological conditions, plankton and soil conditions were studied twice a month Primary production was estimated by the oxygen method. In this series primary production and plankton volume at the end of three months, are furnished below.

	Zn	*Mo*	*Co*	*B*	*Fert control.*	*Unfert control.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Primary production O_2g./m^2/day ..	10·4 11·6	7·2 10·4	3·72	5·16	3·6	3·0
Plankton-centrifuged volume Cc/10 L.	0·50	0·40	0·30	0·30	C·20	0·03

In a second series, the trace elements were added at 0·5 P.P.M. Zinc gave the highest primary production in this series also.

	Zn	*Mo*	*Co*	*Fert-control.*
(1)	(2)	(3)	(4)	(5)
Primary production g. O_2/m^2/day.	18·6–22·6	12·5–29·2	17·0–22·6	4·4.–4·4
Plankton volume Cc/101.	0.3	0·1	0.1	0·02

The rate of primary production was higher at 0·5 P.P.M. than at 0·05 P.P.M. Especially Cobalt and molybdenum were more effective only at the higher concentration of the trace element. With Cobalt and Zinc, initially high numbers of Zooplankters occured but dewindled later whereas molybdenum gave significantly increased Zooplankton with progress of time. Blue green algae, especially *Microcystis* dominated in cobalt treatment and in the case of zinc and molybdenum, more of green algae especially colonial volvocae were noted. At 0·5 P.P.M. Cabalt and molybdenum are costly but zinc is cheaper.

A third series of experiments was run with 0·5 of trace elements and fish fingerlings were introduced and their growth, survival and yield studied for four months. The increase in weight of fish was computed in terms of yield in kg/ha/annum. The results are furnished below.

	Zn	*Mo*	*Co*	*B*	*Control.*
(1)	(2)	(3)	(4)	(5)	(6)
Survival per cent ..	47	13	53	50	23
Yield kg/ha/A ..	2328	360	2444	2508	324

It is clear that Boron treatment has increased the yield to the highest level-higher than with Cobalt and Zinc. At this level zinc was non-toxic to fish. Nor did it have any adverse effect on phytoplankton. Increased formation of Chlorophyll and higher photosynthesis on addition of zinc has been reported[2]. So also Cobalt is reported essential for healthy growth of blue-green algae. The low survival in molybdenum treated ponds is inexplicable. Zinc and Bron appear to be a cheap and effective trace element suitable for increasing fish production.

Our thanks are due to Miss Felicy Antony for identification of the planktonic organisms.

References.

(1) Mortimer, C. H. and Hickting, C. F. " Fertilizers in fish ponds ". Colonial office Fisheries Publication No. 5. HMSO, London 155 P. 1954.

(2) Weissner, W. in Lewin, R. A. "Physiology and Biochemistry of Algae ". Academic Press. New York, 1962. P. 267–286.

1, 2. Hydrobiological Research Station, Madras-10.

SOUTH INDIAN FRESH WATER DIATOMS.

BY

T. FRANKLIN, SECTION OF HYDROLOGY, FRESHWATER BIOLOGICAL STATION, BHAVANISAGAR, SOUTH INDIA.

Introduction.

In India, literature on the Diatoms of brackish and estuarine waters is very meagre. However, Iyengar and Venkataraman (1951) have made detailed analysis of the ecology and seasonal succession of diatoms in the river coovum. Casual references to the distribution of diatoms have also been made by Biswas (1932), Venkataraman (1939). Subrahmaniyan, R. (1946),Chacko and Ganapati (1949). Diatoms of Malayan Fresh Water has been described by Prowse (1962). The diatoms of south Africa have been fully described by Griffen. Cholnoky (1958) has also described many diatom genera. Schmidt's Atlas and van Heurck's works are very essential for identifications.

The contribution deals with diatoms obtained from series of collections made from Bhavani river at different places like Sathyamangalam, Mettupalayam, Bhavanisagar reservoir, Moyar and Aliyar reservoir. Many naviculoid diatoms and centric diatoms are mixed up in the plankton collection. More extensive observation is necessary to identify pennate and centric diatoms. From the collection so far made it was noted that diatoms tend to reach a maximum in early summer, April, May and June. The naviculoid diatoms showed preference for littoral surfaces. Some diatoms like Pinnularia virdis and Nitzschia palea were also found in mud. In addition Nitzschiapalea, appears to be capable of surviving under unfavourable conditions.

A number of species described here are usually regarded as fresh-water forms, it is quite possible that a few of marine orgin, were found in non-saline water, fully alive and often dividing. Such organisms must be highly adatable to survive and multiply in fresh waters (Inland waters). Several species of coscinnodiscus, stephanodiscus, cyclotella and nitzschia fall within this category. Diatoms are widely distributed in fresh water and salt water. They may be free floating often pelagic in habitat. Although diatoms are mostly aquatic many species occur within the soil in wet surfaces.

Reproduction is by cell division, statospores (cysts or endospores) and auxospores.

The description of the available genera follows:—

1. *Amphora Ehrenberg* 1840—*Order Pennales*.—Cells usually sessille ; Girdle view broadly elliptic with truncate ends, the concave faces of the valves being attached girdles usually separated by several punctate or striate intercalary hands ; valve view lunate, longitudinally asymmetric, striae transverse, punctate with central nodule almost adjacent to the margin, Chromatophore single. *Amphora ovalis Kutz Hustedt*, Bac 342 Fig. 628. Amphora ovalis **Kg** and its varieties occured in all collections (Fig. No. 1).

2. *Achnanthes Bory* 1822—*Order Pennales*.—Cells in gridle view rectangular bent or curved longitudinally usually attached by gelatinous stalks, or sessile and united in bundles at the valves, rarely into filaments, occasionally free floting and solitary ; valve view generally linear lanceolate orelliptic, hypovalve usually concave with raphe a distinct central nodule and less distinct polar nodules, the central area sometimes transversely widened into a stauros ; epivalve generally convex with pseudoraphe; transverse striations often somewhat radiate in some species costate ; chromatophores one, two or numerous and discoid. Two auxospores formed from two cells by the conjugation of two pair of gametes.

Achnanthes minutissima K. G. Var. robusta Hust. Fig. No. 2. Order Pennales.—It is small valves more elongated cells lungitudinally curved in girdle view, valves linear to rhombic lanceolate 18—20u ×3u with narrow rounded poles. Striae short marginal very fine, slightly radial.

3. *Cyclotella Kuetzing* 1834.—Cells discoid or drum shaped solitary or colonial, within a mucilaginous envelope, when filamentous the cells not tightly inter locking as in Melosira ; valve view circular, or sometimes eliptic, ornamentation of the valve in two very distinct concentric regions, the outerzone radially striate or punctate the inner zone smooth, or irregularly and finelly punctate, girdle view striaght or undulate, chromatophores numerious, small and discoid Auxospores formed singly within a cell ; some species known to be autogamous.

Cyclotella meneghiniana Kuetzing (*Fig.* 3)—Order Centrales.—Cells 10–25u in diameter outer zone broad with thick well marked striae 7–9 in 10u central zone smooth or with fine radial striae.

Cyclotella species : (Fig. 4).—They occurred in minute size 5u in diameter of two possible species to which it might have affinity cyclotella Kutzingiana. Var. parva, Fricke (Huztedt) Kieselalg. 1·p. 339. Fricke in A.S. Atl. T. 224 (Fig. 37·37 and cyclotella glomerata. Bachmann. (Hustedt, Kieselalg 1·p. 362. Fig. 189) both have differences which made it difficult to assign this form to either of them.

Cyclotella striata (*Kietzing*) *Gronow* : (*Fig.* 5). (Syn. Coscinodiscus striatus Kuetzing).—Cells-25·45u in diameter outer zone broad with well marked striae, every second or third stria marked with a prominent pore ; sometimes very short, or fine marginal striae in between the long ones at a deeper fucus, sub-marginal curves often visible between the pores ; inner zone with irregular swellings.

4. *Cymbella C.A. Agardh*. 1830.—Cells solitary and free floating or attached at the ends of gelatinious stalks, or confined in branched gelatinous tubes ; girdle view rectangular with smooth girdles, intercalary bands absent

valve view asymetric, sometimes only slightly so, lunate or more rarely nearly elliptic rhombic or naviculoid, dorsally convex, ventrally concave, straight or somewhat conve saxial area wide or narrow nearer to the ventral margin central area with or without dots, raphe curved, with well defined nodules; transverse strations radiate; sometimes crossed by longitudinal lines, Chromatophores a single expanded plate. Auxospores formed in pairs between the conjugating cells.

Cymbella lanceolata (Ehrenberg) Van Heurck: (Fig No.6) (Syn. Cocconema lanceolata Ehrenberg)—Valves distinctly a symmetrical, naviculoid, 70—80 u long and 15—120 u wide with a convex dorsal margin and concave ventral margin slightly tumid in the middle, tapering smoothly to be rounded poles; raphe extentric, slightly curved axial area narrow, widening slightly towards the middle; striae at right angles to the raphe in the middle, radial at the poles, 7—11 in 10 u markedly punctate, punctae 15—18 in 10u.

Cymbella Cahuensis Hustedt. (*Fig. No.* 7.—Hustedt. 1942 p. 98 Fig. 193—195 A.S. Atl. 378. Fig. 17—19, Cholnoky 1960 A. p. 34 Fig. 83, 84. This remarkable cymbella previously recorded by Cholnoky. They attain greater length like 39 u Hustedt's figures all show valve with more or less distinctly capitate ends. Dimensions 23—47 u long, 3—6 u broad.

Cymbella Kolbaei Hustdt: (*Fig.* 8).—valves broadly lanceotele asymetric 25—30 u long ×9—11 u wide, dorsal margin very convex, ventral margin less so tapering smoothly to the rounded poles; raphe central, slightly curved, axial area narrow, widening near the middle to an elliptic central area; striae finely punctate 11—12 in 10 u, slightly radial in the middle more or so at the poles; a single puncta in the middle of the central area.

5. *Fragilaria lyngbya* 1819 *Rabenhorst* 1864—Cells united into free floating or sessile colonies, mostly zig, zag chains or ribbons, sometimes flat, stellate colonies; cells rectangular in girdle view with one or two inter calary bands (sometimes none) without septa or costae, valve view linear to fusiform, bilatrally symmetrical, usually attenuated at the poles sometimes capitate and often medianly inflated rarely constricted; transverse striae usually fine, sometimes coarse; pseudoraphe narrow and indistinct to broad and prominent; chromatophores numerous small discoid bodies, or one to four laminate plates with pyrenoids, Auxospores formed singly within the cells.

Fragilaria Vaucheriae. (*Kuetzing*) *Boye Patterson*: (*Fig.No.* 9).—Syn. Synedra Vaucheriae Kuetz. F. intermedia Grunow). Cells 50 to 90 u long × 3—6 u wide, forming closely knit ribbons; girdle view linear-rectangular, valve view elongate-lanceolate, narrowed near the ends, capitate, pseudoraphe narrow; transverse striae, marked, 9—12 in 10 u with a clear central area on one side.

Fragilaria Capucina: (*Fig.* 10).—The rectangular cells are attached in a bundle like fashion. They are small and float in water Cells are compact and numerous striae are noticed. In the middle portion the straie are not distinct.

6. *Gryrosigma hassall* 1845 *em end P. J. Cleve*.—Cells solitary and free-floating, sometimes in gelatinous tubes; girdle view linear lanceolate, intercalary bands and septa absent, valve view distinctly sigmoid usually, gradually attenuated to the broadly rounded poles, sometimes sharply narrowed; raphe sigmoid with small central and polar nodules; axial area narrow and small usually rounded, sometimes asymmetric; central area transverse striae crossed by longitudinal striae at right angles; Chromatophores two regularly or irregularly shaped plates generally with several pyrenoids.

Gyrosigma acuminatum: (*Fig.* 11).—This sp. resembles that of Gyrosigma attenuatum, (Kuetzing) P.T. Cleve (Syn. Pleurosigma attenuatum W. Smith, Navicula attenuata Kuetz Var. attenuata, Kuetz. Pleurosigma attenuatum W. Smith var. caspia Grun). The size may vary from 150—180 u long and 25 to 27 u wide generally attenuated to the rounded poles, raphe centrally placed, central area asymmetric.

7. *Gomphonema C.A. Agardh*. 1824.—Cells usually epiphytic on the ends of dichotomously branched gelatinious stalks, sometimes sessile, more rarely solitary and free floating; gridle view transversely asymmetrical, cuneate the narrowers end being the point of attachment; valve view also transsely asymmetrical, cuneate clavate, lanceolate or nearby striaght with one pole broader than the other, often capitate, axial field narrow, striaght with straight raphe and conspicuous central and polar noduleos; striations transverse parallel or radial central area sometimes extending to the margins, with an asymmetrically placed dot or pore, Chromatophore a single lobed plate, usually with a single pyrenoid. Auxospores formed in pairs between two conjugating cells.

Gomphonema elegans Grun: (*Fig. No.* 12).—The form is Zygomorphic (i.e.) Gomphonema. This has only a single often deeply incised chromotrophore, the median portion of which lies againt one of the girdles, while the rest spreads over on to the valves faces. G. Parvulum var micropus-auxospore formation has been described fully in Geitler. The commonly available species are Gomphonema elegans. Grun.

8. *Melosira C.A. Agardh* (1824).—Cells cylindricalos; united into long filaments; valve view circular, with or without marginal teeth, flat on convex, usually with ornamentations into two district concentric areas, girdles with slucus or grooves, pseudosulcus or without either; when sulcus or psedudosulcus absent central area of girdle usually ornamented, when present central area usually smooth; chromatophores numerous, small, discoid, frequently crowded. Auxospore fromation asexual or autogamous, biflagellate zoospores reported.

Melosira granulata (*Ehrenburg Ralfa* (*Fig.* 13).—Syn. Gaillonella gramulata Ehr., G. Procera Ehr. G. Marchica, Ehr. Melosira ordinata Kuetz., Orthosira punctata W. Smith: Cells 16 long 10 u diameter to 28 long 5 u diameter, slucus shallow and acute; valves with short marginal spines; puctae of valve view large, scattered; gridle view coarsely punctuate, in parallel striations which are straight or only very slighly spiral 8-11 striae in 10 u.

Melosira dubia., Kuetzing, Kieselalg (*Fig. No.* 14)—1 P. 234 Fig. 97.—They are attached to grass stalks, sticks and other algae. The valves show irregular decussating lines of fine puncta 18-20 in diameter.

9. *Nitzschia Hassall* 1845.—Cells solitary and free floating or densely clustered in simple or unbranched gelatinous tubes; girdle view elongate rectangular or sigmoid with somewhat attenuated ploes; valves usually longitudinally asymmetric; rarely symmetric, very variable shape, straight, sigmoid, linear, elliptic, sometimes undulate with or without median constriction, poles acute rostrate or capitate, often much attenuated; raphe in keel which is usually near one margin, rarely central with small nodules and a row of carinel dots opening towards the interior of the cell, keels of the two valves on opposite sides of the longitudinal axis, except where the keel is central; valve transversely striate or punctate and sometimes costate. Two auxospores formed by the conjugation of the cells in somewhat crossed opposition.

Nitzschia palea (*Kuetzing*) *W. Smith* (*Fig. No.* 15). (Syn. Synedra palea Kuetz).—Valves linear 30–50μ long 3–5μ wide with ends narrowing to the hardly sub rostrate to sub-capitate poles; transverse striae very. fine.

Nitzschia subtilis (*Kuetzing*) *Gronow* (*Fig. No.* 16).—(Syn. synedra subtilis Kuetz).—Valves linear-lanceolate 90–130μ long and 3–5μ wide, evenly narrowed to the almost acute poles; Keel excentric. This is wide spread in fresh water regions.

10. *Navicula Bory* 1822 *P.T. Cleve* 1894.—Cells generally solitary and free floating, sometimes aggregated into irregularly radiating clusters, occasionally jointed valve to valve to form ribbons gridle view rectangular, with smooth gridles and without intercalary bands; valve view elongate, lanceolata to elliptic, sometimes with undulate margins, frequently attenuated to capitate, rostrate or rounded poles. Central area variable raphe straight, simple with polar and central expansions, Chromatophores laminate two, rarely four to eight, occasionally with one or more pyrenoids Auxospores formed in pairs by the fusion of two gametes from each of two approximated cells. A very large and variable genus, probably the largest among the freshwater diatoms and often divided into subgenera.

Navicula pseudoholophila, Cholnoky (*Fig. No.* 17).—Navicula pseudoholophila cholnoky 1960—A.P. 74 Fig. 231–235. It occurs in inland and brakish waters. Dimensions long 30–40μ, breadth 7–8μ. Frustules of Navicula are symmetrical in all three planes. The valves are elongate, usually attenuated towards the poles with capitate rounded or rostrate apices. The raphe is distinct axial, straight with well-defined but small central and polar nodules. The frustules are rectangular in girdle view. Most of the species have two laminate chloroplasts.

Navicula longicephala Huts (*Fig. No.* 18).—This is common in fresh water. The two ends are elongated and broader in the middle. The striae are parallel and opposite to each other. The raphe is straight.

Navicula gracilis (*Fig. No.* 19).—This is more or less measuring 20 to 30μ in length. It has the distinct Chloroplast, and striations are not distinct.

11. *Pinnularia Ehrenberg* 1840.—Cells solitary and free floating rarely in short filaments, symmetric and rectangular in girdle view, girdle smooth without intercalary bonds, valves usually with straight or nearly straight sides, sometimes, medianly inflated or undulate; usually with broadly rounded poles; axial field, usually broad, expanded both at the poles and in the middle, with a complex sigmoid or straight raphe; face of valve crossed by distinct transverse coastae with internal openings; costae smooth; radial or parallel (usually convergent at the poles) and with two longitudinal lines often visible in the coastate part of the valve; chromatophores two, laminate usually with pyrenoids.

Pinnularia gibba W Smith var interrupta Fig. No. 20. *A Cleve-Euler.*—Valves narrow linear, lanceolate 65 to 70 μ long × 8-10 wide slightly swollen in the middle and tapering gradually to the broadly sub-capitate poles; raphe linear, hooked at the poles; axial area narrow widening slightly towards the middle where it reaches the margin over a wide area; transverse costae radial convergent at the apices.

Pinnularia viridis (*Nitschi*) *Fig.* 21—*Ehr.*—Frustules are symmetrical. The valves are usually with rounded poles and straight paralled sides. As soon in girdle view the frustules are rectangular, with smooth girdles, and without intercalary bands, within a cell one, two laminate Chromatophores, generally with pyrenoids that lie on opposite sides of the girdle.

12. *Pleurosigma W. Smith* 1852 *emend. P. T. Cleve* 1894.—Cells solitary, elliptic, lanceolate in girdle view; intercalary bands and septa usually absent; valves sigmoid, gradually tapering to rounded or sub-acute poles; raphesigmoid, with small central and polar nodules; axial area narrow, central area usually round, striations consisting of transverse straiæ crossed obliquely in two opposite directions by other straiæ thus making 3 series of striations, Chromatophores two, four or many regular or irregular plates. Two auxospores formed from the conjugation of two cells.

Pleurosigma strigosum W. Smith Fig. No. 22.—W. Smith 1853 p. 64. P. 21.Fig. 203. Pleurosigma angulatum var. strigosa. Van Heurak. 1880–1885. 115: Cleve 1894. P. 41. *PERGALLO* 1897–1908: P1. 32. *Fig.* 22. and 23.—This species occured in numbers in several samples. Dimensions length 126–132μ breadth, 15–16 μ transverse and oblique striae 18–20 in 10μ.

13. *Synedra Ehrenberg* 1830.—Cells narrow and much elongated, solitary or in fan shaped tufts or radiating colonies, free floating or epiphytic, sessile or stalked, valves linear to lanceolate, straight or sometimes curved with poles attenuated or not, often capitate; transverse striations lateral to a conspicuous pseudoraphe, which is usually narrow but sometimes broad; central smooth area present or not, girdle view elongate with truncate ends, straited, chromatophores two large plates, usually with 3 or more pyrenoids in each. Auxospores 1-2 μ each cell, formed in each.

***Synedra Ulna* (*Nitzchs*) *Ehrenberg*.**—Hustedt, Kieselalg 2 p. 195 Fig. 691. A. a-c. Dominant in reservoir waters in early summer(Bhavanisagar reservoir plankton collection) Variable in length dimensions: 114–450 long. Fig. No. 23. Synedra acus.

Synedra acus (*Fig.* 24).—This species is somewhat different with that of synedra ulna Ehrenberg. The species has narrow ends and in the middle it has broader region. It has the variable length. Fig. No. 24.

14. *Surirella Turpin* 1828.—Cells solitary and free-floating; valves-elongate, lanceolate, elliptic or ovate, longitudinally, symmetrical transversally symmetrical or a symmetrical, valve face flat undulate or curved; girdle view rectangular, sinuate or irregular; raphe in a prominent keel or wing on each margin of the valve, connected by a series of canals opening to the interior (wing canals) separated by semi-circular membranes valve face with costae corresponding to the Wing Canals; Chromatophores single; laminate or appearing as two expanded lobes.

Surirella robusta Ehrenburg.—Cells large, distinctly heteropolar in girdle view wedge shaped with flat ends, valve view oval elliptic, 150–250μ long and 50–80μ wide distinctly heteropolar with blunt rounded ends; wings very marked costae prominent 8–15 in 10μ slightly wider than the intercoastae distance, radial at the poles and nearly reducing the middle line, wide spread in fresh water Fig. No. 25.

15. *Stephonodiscus Ehrenburg* 1845.—Cells discoid drumshaped or cylindrical, single and free floating, rarely in chains, valves, circular radially punctate and with a ring of short but stout spines near the margin: girdle view generally somewhat undulate with smooth surfaces and without intercalary bands, chromatophore several small discs or one or two large irregular flat plates largely a marine genus.

Stephano discus Sp.—Cells drumshaped; valves circular 40–50μ in diameter, slightly hollowed in the middle submarginal spines short prominent (Fig. 26).

Acknowledgments.—I wish to acknowledge my thanks and indebtedness to my officer Sri A. Sreenivasan, Assistant Director of Fisheries (Hydrology), Bhavanisagar for his constant interest and for his copies of reprints which were of great help to me.

References.

(1) J. C. Roy—" Periodicity of the plankton Diatoms of the Chilka lake for the years 1950 and 1951 ". Journ. of the Bombay Natural History Society Vol. 52, No. 1 April 54. Pages 113–123.

(2) M. O. P. Iyengar and G. Venkataraman—"Algal flora of the river Coovum (the Ecology and seasonal succession of the algal flora of the river Coovum at Madras with special reference to the diatomaceae) ". The Journal of the Madras University Vol. XXI. July 1951. Pages 190–192.

(3) J. H. " Evans—The Survival of Fresh Water Algae during dry periods " Part I. An investigation of the Algae of five small ponds J. Ecol. 46, 149–167 March 1958.

(4) F. E. Fritsch—" The structure and Reproduction of the Algae " Vol. I, Cambridge at the University Press, 1952.

(5) Gilbert M. Smith—" The Fresh-water Algae of the United States " Mcgraw Hill Book company INC, New York-Toronto London, 1950.

(6) G. A. Prowse—" Diatoms of Malayan Fresh-water " Reprint from the Gardens' Bulletin Singapore Vol. XIX. Part I. 15th October 1962.

(7) Venkataraman, G. 1939—" A systematic Account of some South Indian Diatoms " Proc. Ind. Acad. Sci. 10 (6) 293–368.

(8) Venkataraman, G. 1950—" Contributions to our knowledge of freshwater diatoms of South India " Govt. Press, Madras ".

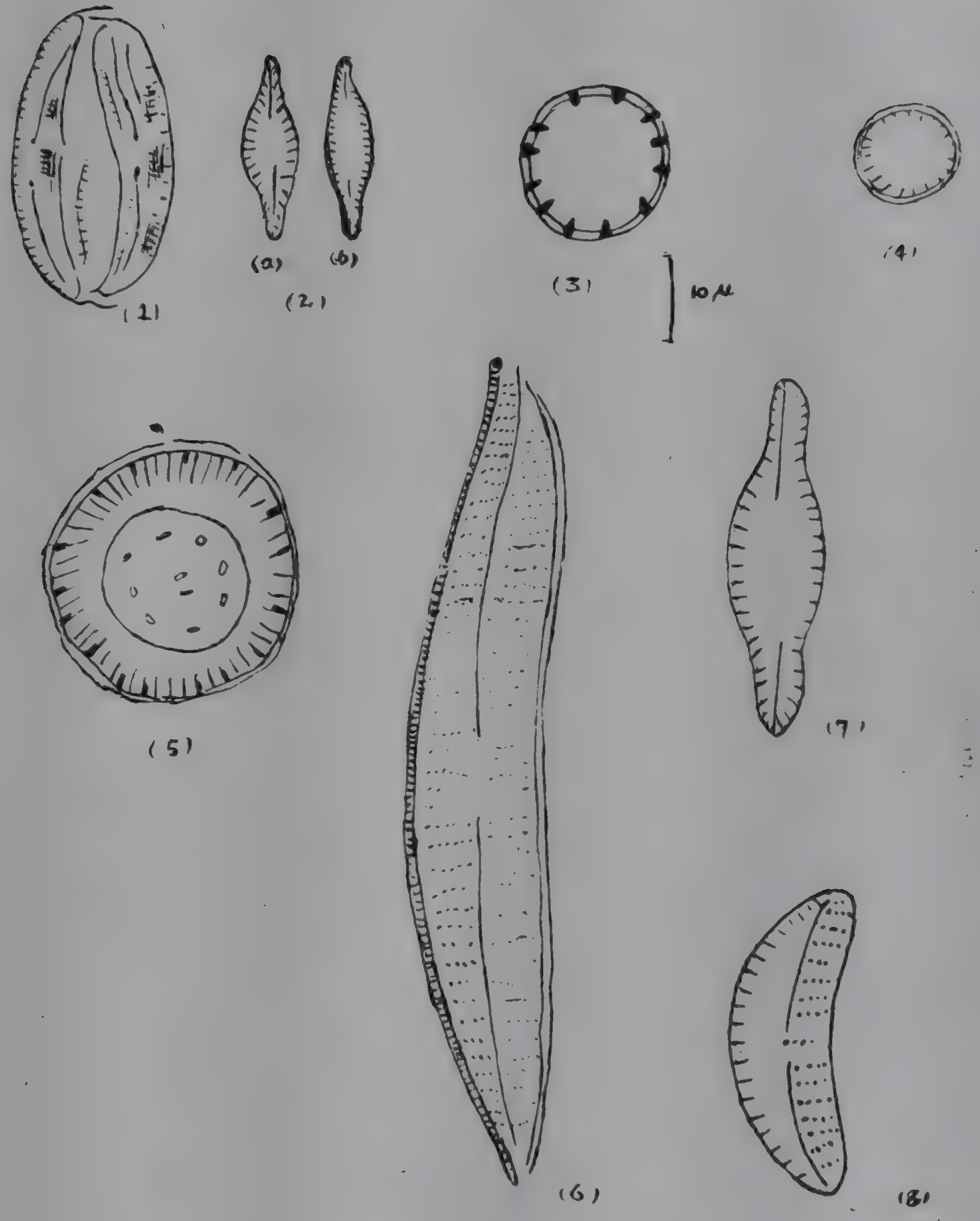
(9) B. J. Cholnoky—" Ein Beetrag Zur. Kenntis Der Diatomeenflora von Hollandisch Neuguinea " Nova Hedwigia-Weinheim Verlagvon J. Gramer 1963. C.S.I.R. Reprint R.W. No. 136.

(10) B. J. Cholnoky—" Ein Beitrag Zu der Okologie der Diatomeen in dem englischen Protektorat Swaziland" —Hydrobiologia Vol. XX. No. 4-10, 12, 1962 Page Nos. 309 to 355.

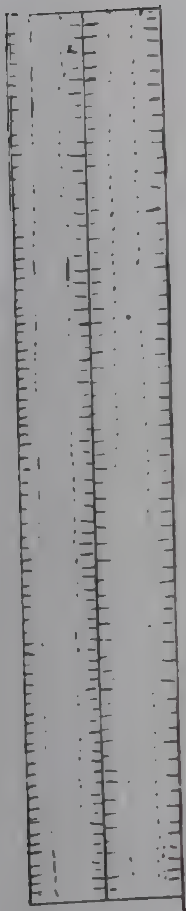
(11) Malco H. G. Giffen—" Contributions of the Diatom flora of South Africa I. Diatoms of the Estuaries of the Eastern Cape province "—Hydrobiologia Vol. XXI No. 3-4. 1-5 Page Nos. 201–263.

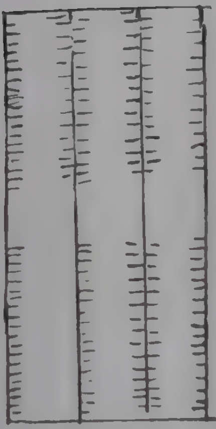
(12) Vladimir Sladecek—"A guide to Limnosaprobical organisms " Department of Water Technology—Prague Scientific Papers from Institute of Chemical Technology, Prague 1963. Technology of Water 7 (2).

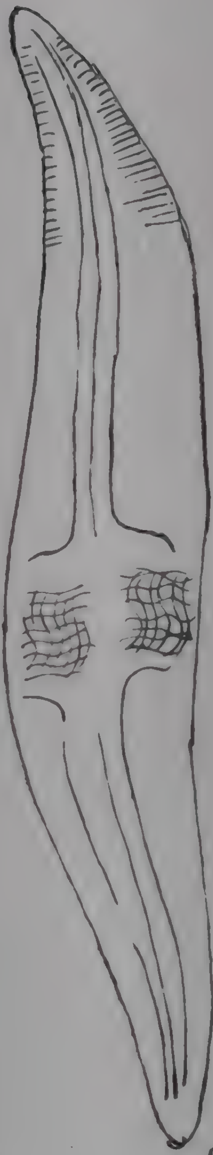
(13) Gilbert M. Smith—" Cryptogamic Botany" Vol. I. Algae and Funji-Mc Grow—Hill Book Company INC, New York, Toronto, London 1938.

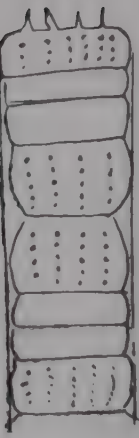


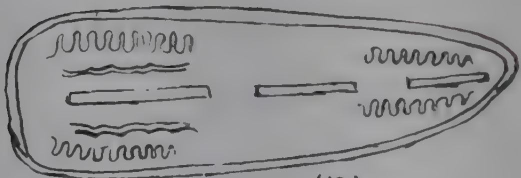
1. **Amphora Ovalis Kutz.**
2. **Achnanthes minutissma K. G. Var. Robusta Hust.**
3. **Cyclotella meneghiniana Kuetzing.**
4. **Cyclotella sp.**
5. **Cyclotella striata (Kuetzing) Gronow.**
6. **Cymbella lanceslata (Ehrenberg) Van. Heurck.**
7. **Cymbella Oahuensis Hustedt.**
8. **Cymbella Koibei Hustedt.**

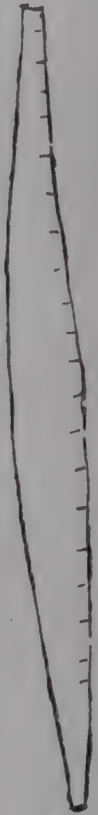

(9)

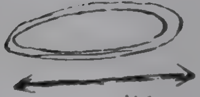

(10)

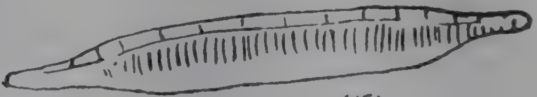

(11)


(13)

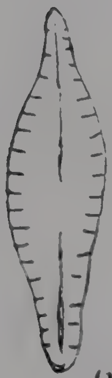

(12)

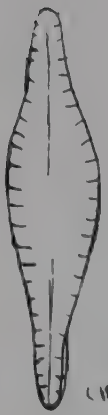

(16)

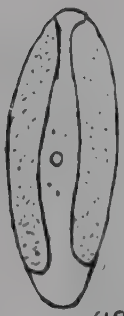

(14)

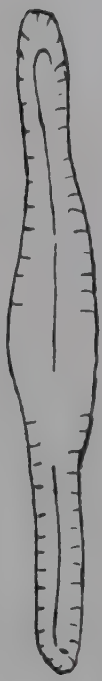

(15)

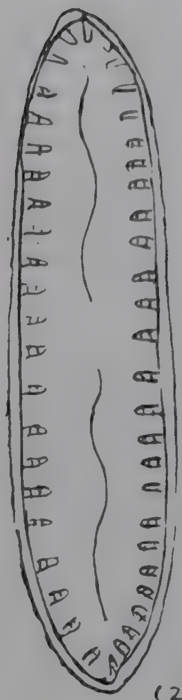
9. Fragilaria Vaucheriae (Kuetzing).
10. Fragilaria capucina.
11. Gyrosigma acuminatum.
12. Gomphonema elegans Grun.
13. Melasira granulata (Ehrenberg) Ralfs.
14. Melosira Agardh.
15. Nitzschia palea.
16. Nilzschia subtilis (Kuetzing).

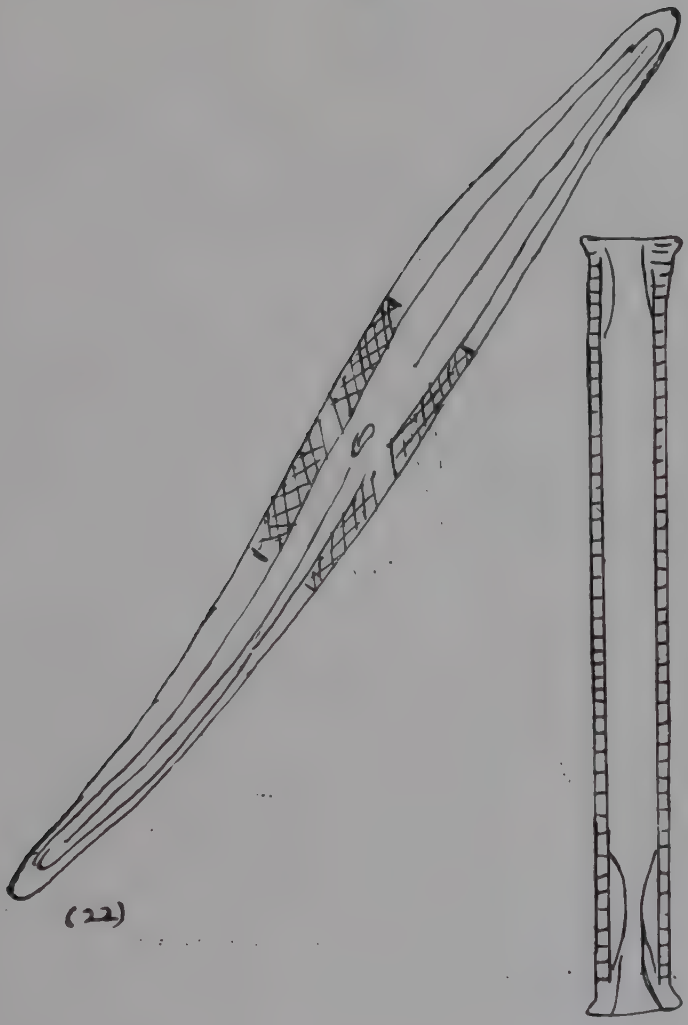

(17)


(18)


(19)


(20)

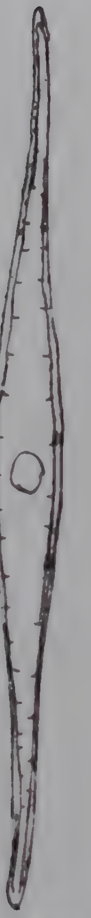

(21)

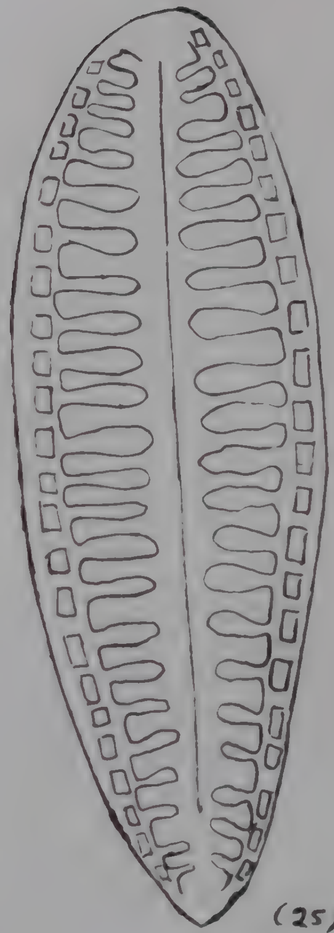

(22)

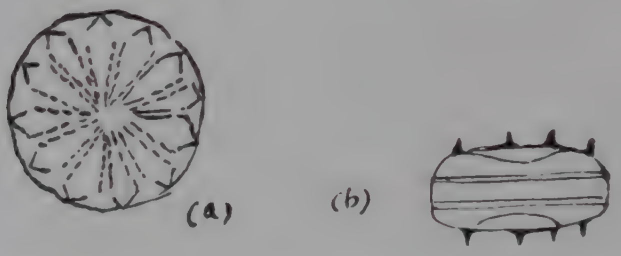
(23)

17. Navicula pseudocephala cholnoky.
18. Navicula longicephala Hust.
19. Navicula gracilis.

20. Pinnularia Gibba W. Smith Var. interrupta A. Cleve Euler.
21. Pinnularia virdis (Nitzschi) Ehr.
22. Pleurosigma slugosum W. Smith.
23. Synedra Ulna Ehrenberg.







24. Synedra acus. 25. Surirella Robusta Ehrenberg.
26. Stephanodiscus sp. (*a*) and (*b*).

ON THE FISH CURING PRACTICES AT CAPE COMORIN.

BY

JOSEPH, K. C. AND SRINIVASAN, R.,
(*Fisheries Technological Station, Madras State*).

I. Introduction.

Cape Comorin, situated at the Southernmost end of our country is an important fishing village on the Madras State Coast. The unique location of the place at the meeting place of three Seas makes fishing operations possible during both the South-west and North-east Mansoon periods. About, 2,500 fishermen are actively engaged in fishing and allied occupations at Cape Comorin.

The annual fish landings at Cape Comorin from 1958 to 1963 and the fishery trend at the place have been detailed by Chacko *et. al.* (1967 loc. cited). Only about 20 percent of the annual fish landings at Cape Comorin is utilised for fresh consumption and the reminder is cured by different methods depending upon the type and size of fish and the markets to which they are intended.

Though some general studies of the fish curing practices in the West Coast of the country had been made by Nicholson (1930), Venkataraman (1951), Venkataraman and Vasavan (1956) and Krishna Pillai *et. al.* (1956) no detailed account of the fish curing actually practiced in the trade for the different varieties of fishes at this important fishing place of Cape Comorin is available in these reports. The present paper aims at supplying this information.

II. Varieties of Fishes caught and processed.

The different varieties of food fishes caught processed at Cape Comorin, their common English names, Scientific names, local names and their approximate annual landings are shown in the order of their commercial importance in Annexure-I.

III. Methods of curing.

(*a*) *Trichiurus sp.* (*Ribbon fish,* " *Savalai* ")—(i) *Dry salting.*—This is done for small sized fish measuring up to 0·4 metres in total length. The fishes are washed well. No gutting is done. The washed fishes are dumped in tubs with salt sprinkled over each layer of fish of about 10-15 cm. thickness, the ratio of the total weight of salt used to the weight of fish cured being 1 : 6. This is kept in the tubs overnight during which period the self brine formed accumulates in the tubs. The period under cure varies from 12-20 hours depending on the time of landing the catch. Catches landed in the morning will have the maximum period under cure until the next morning and the catches landed in the afternoon will be under cure for less duration. The fishes are removed the next morning by about 9-00 hours and spread on coir mats for drying in the sun usually up to about 16-00 hours, the duration of drying being about 7 hours a day. The drying is done in such a way that the heads of the salted fishes point westward until noon when the position is reversed with the heads pointing east and the side which was in contact with the mat being now exposed to the sun. The products intended for certain markets such as Changanachery are dried only for one day whereas those for the Madras City markets are dried for two consecutive days. The dried fish is packed using palmyrah leaf mats in bundles weighing a hundred weight each. During periods of glut when heavy catches have to be handled no regular arrangement as described above is observed for the drying.

(ii) *Wet salting.*—This is resorted to generally for large sized specimens measuring above 0·40 metres inlength. The washed fish is salted; in the salt fish : proportion of 1:4. The curing is done in tubs or pits or by heaping the salted fish on a cement floor. In tubs the fish and salt are placed in alternate layers. In the case of pit curing the fishes are so stacked that the ventral side of each fish covers the dorsal side of the nearest placed fish. Over each such layers salt is sprinkled and the next layer of fish will be spread at right angles to the previous layer. The maximum depth of a pit will be about 1·6 metres and the bottom and sides of the pit will be lined with palmyrah leaf mats. After placing the salted fish a layer of mats is placed to cover the fish. Above this the pit is filled with soil to about 0·3 metre thickness. The soil is pressed down by trampling and by placing of stones above the soil. On the third day the cured fishes are taken out of the pits, tubs or the heaps as the case may be and are packed in mats with salt in the salt: fish ratio of (1:8). The chief markets for this type of products are Kovilpatti, Melapalayam and Valliyoor.

(*b*) *Anchoviella sp.* (*White baits, "Nethali"*).—No salt curing is done for this tiny fish. This is merely dried in the sun. The drying is done by spreading the catches on the ground. While drying, the fish is occasionally turned to facilitate uniform and faster drying. For the second day's drying the partially dried fish are spread in a layer of about 15 cms. thickness over coir mats for further drying. The dried fish is packed in palmyrah mats.

(*c*) *Serranus, lutjanus, Lethrinus, Diagramma, Aprion, Sciaena, otolithus and Drepane*—(i) *Dry salting.*—The fishes are descaled and the top portion of the heads including the eyes is hacked off. These are then slit open completely from the dorsal side so that the back bone will be retained on one side. The entrails and gills are removed. Then longitudinal cuts are made, the tail end remaining in one piece. The back bone is separated from the flesh, by passing the knife below it but the bone is not removed. These are then washed, cleaned and salted in tubs with salt fish proportion as 1:4. The fish remains in contact with the self brine over night. The period under cure may vary from 12 to 20 hours depending upon the time of landing of the catch. After curing the fishes are washed in the self-brine to remove the undissolved salt sticking to the flesh and dried on coir mats for 2 to 3 days. During drying individual pieces are turned occasionally to ensure even and quicker drying. The dried fish are stored heaped on coir mats inside godowns until they are packed in bundles in palmyrah leaf mats for despatch. Such products are mainly meant for export to Ceylon.

(ii) *Wet curing.*—Scales are not removed. A deep incision is made along the dorsal side from behind the back of the head to behind the dorsal fin and the entrails are removed. These are then washed cleaned and salt placed inside the slit (Salt : fish = 1 : 3). These are now placed in tubs pits or sometimes heaped on the floor for 2-3 days. The self-brine is allowed to drain off. On the second day the fishes are resalted with a further quantity of salt (Salt : fish = about 1 : 8). After the third day the fishes are packed in palmyrah leaf mats with a further sprinkling of salt.

(*d*) *Cybium, Caranx, Chorinemus, Histiphorus sp. and Megalaspis sp.*—In these varieties the scales are not removed. Both dry and wet salting are employed, the methods being the same as described above for Serranus, etc. [*Vide* paragraph (*c*) above].

(*e*) *Stromateus sp.* (*Pomfrets*).—This fish is cured by the wet curing methods only, the procedure being the same as in paragraph (*c*) above.

(*f*) *Arius sp.* (*Cat fish*)—(i) *Wet salting.*—This is wet cured in pits. The fishes are slit along the dorsal side and entrails removed, washed and salted, the salt fish ratio is 1 : 3 and put in pits. The pits are prepared as for Ribbon fish described earlier. On the second day the pits are opened, the fishes resalted (1 : 4) and put in the same pit where it remains for another 2 to 3 days. The fish is then removed and packed in palmyrah leaf mats.

(ii) *Dry salting.*—Method is the same as described for *Caranx*, etc.

(*g*) *Lactarius sp.*—(i) *Wet salting.*—The fishes are slit from the dorsal side for about 5 cm., and salt put into the slits; guts and gills are not removed; Salt : fish=1 : 4.

The salted fish is placed in tubs and the self-brine formed allowed to drain off. Instead of tubs, pits are also made use of; curing period is from 24 to 48 hours. Afterwards the fish is removed and resalted to fill the slits (1 : 6) and packed with a sprinkle of salt (1 : 15).

(ii) *Dry salting*—(a) *For small sized fishes.*—The fishes are slit and salted as above and spread in layers in tubs with a sprinkle of salt and are kept overnight so as to remain in contact with the self-brine formed. After curing the fishes are washed in the self-brine and dried in the sun for two days.

(b) *For larger sized specimens.*—The fishes are slit open by cutting along the dorsal side, guts and gills are removed, washed and salted, salt : fish ratio being 1 : 8. The salted fish is kept in tubs overnight so as to remain in contact with the self-brine formed. After curing the fishes are washed in the self-brine and dried in sun for 2 to 3 days.

(*h*) *Dussumieria*—(*Rainbow Sardines*)—*Wet salting.*—The catches are heaped on a cement floor and salt lavishly sprinkled after each layer of fish. The salt : fish ratio at this stage will be 1 : 4. After four hours the heap is resalted (1 : 12). The brine formed flows off. After 12 hours the fish is packed with a further sprinkling of salt (1 : 12).

(*i*) *Sardinella sp.* (*Sardines*).—Sardines are usually cured by the wet salting method only. The processing is the same as described above for Dussumieria except tha no second salting is done at the 4 hours stage. Th curing may be done either in heaps as for Dussumieri or in cement tubs or pits dug in the soil.

(*j*) *Sharks, Skates and Rays.*—For sharks and skates, th fishes are prepared for salting according to the followin method. The heads are removed and the remainin portion is first cut into pieces measuring about 30 to 50 cm long. Each such piece is split open and cut longitudinall so that at one end all the cut pieces will be joined togethe The back bone is also retained along with the flesh. Ther is also another practice of making incisions into the fles without piercing the skin instead of longitudinal cuts.

For rays the method of cutting is slightly differen The tail and the skin above the back bone are first cut of The ray is then cut into two halves by a longitudinal cu along the middle of the dorsal side. The two halves ar further cut into smaller pieces by transverse cuts. Sever incisions are then made into the fleshy portion withou piercing the skin.

(i) *Wet salting.*—The method of salting and curi is the same for all the three varieties. The cut pieces a washed and salted in the salt : fish ratio of 1: 4 by weig and are then put into tubs where it remains in conta with the self-brine formed usually for three days or un required for the markets. Instances of wet cured sha kept in the self-brine for periods of up to even 4 months a common.

(ii) *Dry salting.*—The processing method is t same as above with the exception that the cured fi pieces are taken out of the self-brine on the 4th day a dried in the sun for four to six days.

(*k*) *Leiognathus sp.* (*Silver bellies*)—(i) *Wet salting.* This is done for the large sized specimens only. A de cut of 1 cm. is made across the belly and then the fish are mixed with salt in the proportion 1 : 6 and hea over a cemented floor. After about 4 hours the hea resalted by sprinkling more salt (1 : 10). After 12 ho under cure the fishes are packed.

(ii) *Dry salting.*—Large specimens after curing described above are dried in the sun for two days. Sn sized specimens are merely salted (1 : 6) and dried.

(*l*) *Balistes*—*Dry salting.*—The fishes are skinned pealing of the skin behind the pectoral fins and intestines removed from the ventral side. The en operation is done manually without the use of a kn The skinned samples are then salted (Salt : fish=1 : and kept in tubs, pots or pit for 18 hours followed by dry for two days.

(*m*) *Sphyraena sp.*—Both wet and dry salting employed for curing the fish. For small specin the methods are the same as described above for *Lacta sp.* and for larger ones the methods of curing both wet dry are as for *Caranx sp.*

(*n*) *Upeneoides*—(i) *Wet salting.*—The fishes are sc washed and salted (Salt : fish= 1: 4) and kept in overnight the self-brine being drained off. Next the fishes are packed with a sprinkling of salt (Salt : f 1 : 10).

(ii) *Dry salting.*—The fishes are scaled, washed and salted as above for the wet salting, but the self-brine is allowed to accumulation of tubs, where it remains overnight. Then the fishes are taken out and dried for two days before packing.

(*o*) *Pristipoma sp.*—The curing methods, both wet and dry, are the same as for Silver bellies.

(*p*) *Thynnus sp. and Elacate sp.*—The methods of curing are the same as for Cybium and Caranx described earlier.

(*q*) *Otolithus sp. and Drepane sp.*—The methods of curing for these varieties are the same as for Serranus.

(*r*) *Hilsa sp. and Minimaculate sp.*—The same methods as for Silver bellies are employed for curing these fishes.

(*s*) *Pellona sp. and Albula sp.*—These two varieties are merely salted (1 : 5) kept overnight and dried in the sun.

(*t*) *Mackerals.*—Only small size Mackerals are available in this area and these are sun dried without salting.

(*u*) *Decapterus sp.*—Large sized specimens are cured as in the case of Sardines. Small sized fish sp., is merely sundried as for White baits.

(*v*) *Mugil sp.*—The fish is not cured at all. The small quantity that is caught is used for fresh consumption.

A survey of the quality of the cured fish products produced in Kanyakumari district including Cape Comorin has been made by Srinivasan and Joseph (1966). The survey has revealed that the keeping qualities of these products are far from satisfactory. This is attributable to the factors listed below :—

(1) Time lag between catching and processing,

(2) Rough and careless handling of the catches on the catamarans, at the landing centre and during transport and processing at the curing yard,

(3) Unhygienic conditions in the landing centre, curing sheds and drying grounds,

(4) Lack of adequate water supply at the curing yards,

(5) Existence of consuming centres where any quantity of utterly rotton fish is in great demand.

The following remedial measures are suggested in this connection :—

(1) Provision of larger and faster craft to gradually replace the existing fleet of catamarans.

(2) Provision of Ice Plant and Cold Storage facilities.

(3) Better sanitation on shore and the landing centres. The existing practice is to dump all the catches on the sandy shore of the fishing village before sales to processing merchants. The catches thus get spoiled by admixture with sand and dirt, bacterial contamination and also by exposure to the hot sun. A shed with cemented floor will have to be provided for this purpose with adequate water supply for daily cleaning.

(4) Improvements at the fish curing yard. Provision of adequate water supply is the most important requirement here. A good drainage system for the self-brine and washings has to be provided. The application of disinfectants in the cutting sheds, washing and curing tubs at regular intervals is a necessity to ensure better cured products. This will have to be done at least once in a week with chlorinated water (50 p.p.m. available chlorine which can be easily prepared with sodium hipochlorite.

V. Acknowledgment.

We are thankful to the Director of Fisheries, Madras, for his kind permission to publish this paper.

We are also thankful to Sri J. P. Thompson, Sub-Inspector of Fisheries, Cape Comorin, for assistance in collecting details of some of the curing methods.

References.

Chacko, P. I., Srinivasan, R., Mrs. Abraham, J. G. Radhakrishnan Nair and Ananthanarayanan, R.—" On the fish landings and fishery trend at Cape Comorin "—Madras Journal of Fisheries. III, 121–125.

Nicholson, F. A. (1930)—" The preservation and curing of fish "—Government Press, Madras.

Krishna Pillai, V., Valsan, A. P. and Rajendran Nair, M. (1956)—" Studies on the chemical quality of cured fish products from the West Coast of India ".—Indian Journal of Fisheries, 3, 43–58.

Venkataraman, R. (1951)—" Fish curing in India " Ed. B. N. Chopra, Ind. Fisheries-I.P.F.C., 1951.

Venkataraman, R. and Vasan, A. G. (1956)—" Salt Curing of the Marine Fishes of the West Coast (Madras State) ". Fisheries Station Reports and Year Book, 1954–55, 391–416.

Srinivasan, R. and Joseph, K. C. (1966)—" A survey of the quality of salt cured fish produced in the Kanyakumari District, Madras State ". Proc. 53rd Indian Science Congress Abstract No. 120, of Part III, 380.

ANNEXURE I.

SHOWING THE DIFFERENT VARIETIES OF FOOD FISHES CAUGHT AND PROCESSED AT CAPE COMORIN, THEIR ENGLISH NAMES, SCIENTIFIC NAMES, LOCAL NAMES AND THEIR APPROXIMATE ANNUAL LANDINGS.

Serial number and common English name. (1)		*Scientific name.* (2)	*Local name in Tamil.* (3)	*Approximate annual landings.* (4) TONNES.
1	White bait	Anchoviella sps.	Nethali	500
2	Ribbon fish	Trichiurus sp.	Savalai	500
3	Horse Mackeral	Caranx sp.	Parai	160
4	Big Jawed Jumper	Lactarius sp.	Kuthippu	220
5	Rainbow Sardines	Dussumieria	Mural, Thondan	80
6	Sharks, Skates and Rays	Elasmobranchs	Sura, Uluvai and Thirukkai	34
7	Rock Cod	Serranus sp.	Kalava	50
8	Seer fish	Cybium sp.	Cheela, Neymeen	50
9	Sardines	Sardinella sp.	Chalai, Choodai, Kirimeen salai	28
10	Cat fish	Arius sp.	Keluthi	35
11	Sea Bream	Lethrinus sp.	Vilameen	40
12	Pomfret	Stromateus sp.	Vaval	13
13	Jew fish	Sciaena sp.	Paluthai, Kattalai	19
14	**Barracuda**	Sphyraena sp.	Neduva; Ooli	10
15	Silver bellies	Leiognathus sp.	Karal	20
16	Trigger fish (Filefish)	Balistis	Klathy	4
17	Queen fish (Leather Jacket)	Chorinimus sp.	Katta	9
18	Sharp toothed bass or Job fish	Aprion sp.	Lomia	18
19	Red Snapper	Lutjanus sp.	Chevva, Cheppili	22
20	Grunteror Javalin fish	Pristipoma sp.	Konankora	4
21	Spade fish	Drepane sp.	Painty	2
22	Sabre fish	Chirocentrus sp.	Mulluvalai	6
23	Torpedo Trevally	Megalaspis sp.	Vankadai	7
24	Red Mullet (Goat fish)	Upeneoides sp.	Nakarai	5
25	Sail fish	Histiophorus sp.	Thalai	1
26	Jew fish	Otolithus sp.	Panna	1
27	Sweet lip	Diagramma sp.	Madanam	3
28	Indian Herring	Pellona sp.	Kutha, Poovali	2
29	Gray Mullets	Mugil sp.	Manalai, Madavai	Less than 1
30	Butter fish	Elacate sp.	Kadal viral	Less than 1
31	Round scad	Decapterus sp.	Kozhu chalai	7
32	Indian Shad	Hilsa sp.	Kazhuthamathi, Ullam	Less than 1
33	Rat fish	Albula sp.	Elimeen	Less than 1
34	Tuna	Thynnus sp.	Choorai	Less than 1
35	Moon fish	Minimaculate sp.	Kanndi karal	Less than 1

STUDIES ON THE OPTIMUM MOISTURE CONTENT OF DRIED WHITE BAITS (ANCHOVIELA SP.)

By

JOSEPH, K. C. and SRINIVASAN, R., Fisheries Technological Station, Madras State.

Introduction.

In an earlier communication (Srinivasan *et. al.* 1965), the results of studies carried out on the quality of dried white baits (*Anchoviella sp*). in the trade were reported. The chief defects noticed in the trade samples of dried white baits were their relatively high moisutre content, heavy admixture of sand and limited shelf life. With a view to improve the qulality of the products in the trade, the Indian Standards Institution has also prescribed quality standards for dried white baits (I.S. 2833—1964). The method of curing white baits in India is by sun-drying alone except in the Kerala State where this fish is occasionally salted in the rainy season before drying. Being an unsalted product the useful shelf life of sun-dried white baits depends to a large extent on the moisture content. In the earlier investigation on the quality of dried white baits in the trade (Srinivasan *et. al.* 1965 loc. cited) it was found that 78 per cent of the samples studied had moisture content of above 15 per cent. The usual explanation of the trade for the poor quality of dried white baits because of inadequate drying is that further drying would result in increased breakage of the white baits and thereby the product would fall in consumer appeal. It was mainly with a view to assess the basis of this contention and to ascertain the optimum moisture level to ensure the maximum storage life for the product that the present studies were undertaken. Sun-dried white bait samples ranging in moisture content from 6·8 per cent to 24·3 per cent were prepared, packed and stored under the same conditions in practice in the trade and the progress of spoilage studied with particular reference to breakage.

The results are presented in this paper.

Materials and methods.

Freshly landed white baits were purchased from Cape Comorin and dried in the sun for varying durations During the course of the drying which was done by spreading the fishes on the sandy drying ground of the local Fish Curing Yard, the fishes were occasionally turned to ensure quick and uniform drying. The daily hours of drying were between 09·00 hours and 17·00 hours. Between successive days of drying the material was stacked in heaps on the cemented floor of the godown. The prevailing atmospheric conditions, viz., the maximum and minimum temperatures and the relative humidity were noted as recorded at the local Meteorological Centre. The dried fish was packed in palmyra leaf mat bundles and the progress of spoilage was assessed at fortnightly intervals until adjudged unfit for human consumption. The organoleptic characteristics, assessed included appearance, texture, flavour, odour fungal attack and insect infestation. The samples were also analysed for moisture, acid insoluble, ash, sodium chloride, total volatile basic nitrogen and breakage. Moisture, acid insoluble ash and sodium chloride were determined as per A.O.A.C. methods of analysis (1965). Conway's micro diffusion method of analysis as modified by Beatty and Gibbons (1937) was adopted for the estimation of total volatile basic nitrogen. Breakage was determined in terms of the weight in grams of the broken pieces in 100 grams of the dried or fresh sample as the case may be.

As no apparent relationship could be found out between the moisture content and the breakage in the sun-dried samples during storage, observations were made on the methods of handling of the freshly landed white baits from the landing place to the drying ground. The extent of breakage in the freshly landed product at the landing centre and during handling prior to drying was determined.

Results and conclusions.

The results of the storage studies on 13 samples of sun-dried white baits are presented in Table I and the results of observations on the breakage of the fresh fish up to the time of drying are given in Table II.

Sun-drying of fresh white baits with theduration of drying varying from 8 hours to 70 hours gave dried products having moisture content varying from 24·30 per cent to 6·81 per cent. It was found that under the normal conditions of sun-drying at Cape Comorin the moisture level could be brought down to around 15 per cent in white baits dried for two days. As will be seen from Table I, the samples numbered 7 to 13 were prepared out of the same fresh material by continuously drying for up to ten days withdrawing dried samples daily from the second day onwards until the seventh day and the final samples on the tenth day. In these samples the moisture content was reduced to 12·83 per cent on drying for 16 hours; 10·63 per cent after 24 hours; 10·10 per cent after 30 hours; 9·83 per cent after 35 hours; 7·23 per cent after 42 hours; 6·90 percent after 48 hours and 6·81 per cent after 70 hours of drying in the sun. The reduction in the level of moisture was nearly 60 per cent on the first two days (16 hours) 2·20 per cent on the third day (8 hours), 0·53 per cent on the fourth day (6 hours), 0·27 per cent on the fifth day (5 hours), 2·60 per cent on the sixth day (7 hours), 0·33 per cent on the seventh day (6 hours), and 0·09 per cent on the last three days, viz., the eighth, ninth and tenth days (22 hours). Hence it appears that a moisture level of around 7·0 per cent is the minimum attainable by sun-drying of white baits within a reasonable period under the prevailing atmospheric conditions of Cape Comorin. The maximum temperature during the ten days period ranged between 28·2 degree centigrade to 31·8 degree centigrade and the minimum temperature between 23·0 degree centigrade to 26·6 degree centigrade. The relative humidity ranged between 62·0 per cent to 98·0 per cent, the average value being 78·3 per cent.

In the earlier communication (Srinivasan *et. al* 1965 Loc. cited) the authors had experssed the view that " it might be possible to improve the shelf life of the product considerably if the product was dried to 15 per cent moisture level as in such perfect dried products, a good portion of the adhering sand particulars might also fall off." In the present study the percentage of acid insoluble ash owing to the admixture of sand with sun-dried white baits was found to vary between 1·63 and 3·87 on the dry basis, the average value for the 13 samples being 2·73 per cent. However it was seen that the quantity of acid insoluble ash due to sand particles sticking to the dried white baits had no relationship to the moisture content of the product within the range of moisture levels obtained in the present series of experiments.

The percentage of sodium chloride on the dry basis ranged from 1·43 to 1·76, the average value for the 13 samples being 1·62 per cent. In the absence of any salting a higher NaCl content could not be expected.

The initial T.V.B.N. values ranged between 52·5 mgm/100 gms. to 112·0 mgm/100 gms. In the samples with moisture content of above 15 per cent the T.V.B.N. values rose to 200·0 mgm/100 gms. after a storage period of 10–12 weeks when these were found unfit for human consumption. In the samples within the moisture range of 12–15 per cent a corresponding stage was reached at the end of 12 weeks storage. In the rest of the samples, i.e., having moisture content of less than 12 per cent (6·81—10·63 per cent) a comparable level of T.V.B.N. values was noticed after a storage period of 16–18 weeks. In other words the progress of spoilage based on the T.V.B.N. level as index was proportional to the level of moisture in the thirteen samples of dried white baits studied ; the shelf life of the product increased with the decrease of the moisture level. This was further proved by the results of the organoleptic assessment of the samples.

The organoleptic characteristics, of texture, flavour, odour, fungal attack and insect infestation were found progressively better the drier the products were. The only drawback noticed with reference to the more dried samples was that the normal greyish white appearance of the sun-dried white baits was lost and the product changed to brownish or dark brown colour quicker than the less dried products. This, according to the trade is not appreciated by the consumer. But for this relatively minor disadvantage, the consumer has nothing to lose by having the white baits dried to a lower level of moisture than that practised at present.

The usual excuse of the trade for not adequately drying the white baits is that by further drying, the final product is liable to more breakage during drying, storage and handling. On the face of it, this appears to be a reasonable fear as the white baits might become more brittle on drying. But the present investigation has shown that the extent of breakage was not related to the moisture content of the samples as will be seen from Table I. Therefore investigations were carried out to trace the source of breakage. As seen from the data in Table II breakage in sun-dried white bait is attributable to the rough and careless manner in which the fresh fish is handled during processing. The freshly landed material on the beach in one instance had breakage of only 0·32 per cent. The very same material packed in baskets when transported to the drying ground showed breakages of 1·71 per cent, 3·04 per cent and 6·33 per cent in the case of three basket loads on unloading at the drying ground. This is because of the prevailing practice by which basket loads of fresh white baits, each weighing about 40–50 k. gms. brought by headloads to the drying ground from the landing centre by the porters are emptied on to the ground by simply tilting the baskets, resulting in the material falling enmass through a height of nearly two metres. Of course the porters do this to save time in their anxiety to return to the landing centre to bring the next basket load as wages for this item of work are in terms of the number of trips performed. However, the impact of this dumping is so heavy, especially where the drying ground consists of hard soil, that a good number of the fresh white baits, which are well known for their soft and non-fibrous flesh, get completely smashed and shatterd to pieces. Hence considerable increase in the breakage as already mentioned above takes place at this stage. The next stage in the operations consists of spreading the fishes on the open sandy beach by hand, the process invariably causing heavy admixture of sand to the product. In the experimental observations conducted with the co-operation of the curers themselves it was found that as a result of this hand spreading and drying of the fishes on the sandy beach, the breakages in the three cases had increased to 2·13 per cent, 3·27 per cent, and 7·05 per cent respectively by the completion of the first day drying. The extent of the breakages was further determined at the end of the second day drying also. Usually for the second day drying, the partially dried white baits are spread in a thick layer over coir mats and there is very little handling of the product. except poking, three or four times to ensure uniform dryage. The breakage figures at this stage were more or less the same as at the end of the first day drying. The percentages in the three lots were 2·12, 3·30 and 7·12 respectively. Thus it is seen that more careful handling of the fresh fish on the boats, at the landing centres and during transport to the drying ground as well as stoppage of the unscrupulous practice of the drying and hand spreading of the fresh white baits on the open sandy beach will go a long way to improve the quality of the product and reduce the chances of breakage in sun-dried white baits.

From these studies made it is also concluded that the optimum moisture content of dried white baits (*Anchoviella sp.*) can be taken as 12 per cent, the product having a shelf life of about 12 weeks. Products with lower moisture levels though kept well their chemical characteristics upto 16 to 18 weeks, developed soon a brownish colour not liked in the trade. There is no relationship between the moisture level of the product and its breakage. The general belief that perfect drying of the product might increase breakage is unfounded. Careful handling of the fish at all stages and drying on palm or coir mats instead of on the open sandy beach will considerably improve the quality of the product in the trade.

Summary.—The chief existing method of preserving white baits (*Anchoviella Sp.*) in the Madras State is by sun-drying. Being an unsalted product it is essential to reduce the moisture content of dried white baits to around 12 per cent by weight in order to ensure good keeping qualities and maximum storage life of about 12 weeks for the product. Careful handling of the material during all the various stages of processing will improve the product considerably and reduce the extent of breakages, a common feature of sun-dried white baits in the trade. The general belief among fish curers that by perfectly drying the product the breakages will increase is unfounded.

Acknowledgement.

Thanks are due to the Director of Fisheries, Madras, for his kind permission to publish this paper.

References.

(1) Beatty, S. A. and Gibbons, N.E. (1937)—Journal of the Fisheries Research Board of Canada, 3, 77.

(2) Conway, E. J. (1947)—"Micro-Diffusion Analysis and Volumetric Error", Crosby Lockward and Son.

(3) Indian Standard Specification No. 2883—1964—Indian Standard Specification for dried white baits.

(4) Methods of Analysis (A.O.A.C) (1955)—(8th Edition).

(5) Srinivasan, R., Sabapathy, N. and Joseph, K. C. (1965)—"A Study of the quality of dried white baits in the trade", 9th I.S. Convention at Bangalore S-4 Technical Session on Implementation of Food and Agricultural Standards. Paper No. 15.

TABLE I—*Showing Results of storage studies on white Bait dried to* ***Different Moisture Levels.***

Serial number of sample.	Duration of drying (number of hours).	ATMOSPHERIC CONDITIONS DURING DRYING.										
		Days of drying.	*First.*	*Second.*	*Third.*	*Fourth.*	*Fifth.*	*Sixth.*	*Seventh.*	*Eighth.*	*Ninth.*	*Tenth.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	8	R.H. (Per cent).	72·0	74·0	..	..	..	..	..	..	..	..
		Max. Tem. (° C).	31·8	31·0	..	..	..	..	..	..	..	..
		Min. Temp. (° C).	24·9	24·7	..	..	..	..	..	..	..	..
2	8	R. H. (Per cent)	75·0	77·0	..	..	..	..	..	..	..	..
		Max. Temp. (° C).	29·8	29·8	..	..	..	..	..	..	..	..
		Min. Temp. (° C)	23·5	24·2	..	..	..	..	..	..	..	..
3	10	R. H. (Per cent)	72·0	74·0	..	..	..	..	..	..	..	..

		Max. Temp. (° C).	31·8	31·0	..	..	..	..	..	..	..	..
		Min. Temp. (° C)	24·9	24·7	..	..	..	..	..	..	..	..
4	12	R. H. (Per cent)	75·0	77·0	..	..	..	..	..	..	..	..
		Max. Temp. (° C)	29·8	29·8	..	..	..	..	..	..	..	..
		Min. Temp. (° C).	23·5	24·2	..	..	..	..	..	..	..	..
5	[illegible]	R.H. (Per cent)	75·0	60·0	82·0	..	..	..	..	..	..	..
		Max. Temp. (° C)	29·7	31·1	30·2	..	..	..	..	..	..	..
		Min. Temp. (° C)	24·6	24·2	23·6	..	..	..	..	..	..	..

Table I—*Showing Results of Storage studies on White Bait dried to different moisture levels*—cont.

Serial number of samples.	Factors determined.	(Period of Storage) (Number of Weeks.) 0	2	4	6	8	10	12	14	16	18	20
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1	Appearance	Good.	Good.	Good.	Fair.	Fair to poor.	Fair to poor.	Very poor.	Unfit for Human consumption.			
	Texture	Medium hard.	Medium hard.	Medium hard.	Soft	Soft.	Soft.	Soft.				
	Flavour	Good.	Good.	Good.	Good.	Fair.	Poor.	Unpalatable.				
	Odour	Good.	Good.	Good.	Faintly Ammoniacal.	Slightly Ammoniacal.	Ammoniacal.	Putrid.				
	Fungi	Nil	Nil	Nil	Nil	Nil	Present.	Present*				
	Insects	Nil	Nil	Nil	Nil	Nil	Nil	Present.*				
	Moisture (Per cent)	24·30	..	..	..	..	..	..				
	Acid Insol. Ash (Per centage on D.B.)	2·33	..	..	..	..	..	..				
	Sod. Chloride (Percentage on D.B.)	1·608	..	..	..	..	..	..				
	T.V.B.N. (mgm./100 gm.)	70·0	..	..	98·00	40·0	89·0	66·0				
	Breakage (gm./100 gm.)	0·6	0·70	0·65	1·1	1·25	1·35	1·35				
2	Appearance	Good.	Good.	Fair	Fair to poor.	Poor.	Very poor.	..	Unfit for Human consumption.			
	Texture	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Soft.	..				
	Flavour	Good.	Good.	Fair	Fair.	Fair.	Unpalatable.	..				
	Odour	Good.	Good.	Slightly Ammoniacal.	Slightly Ammoniacal.	Ammoniacal.	Strongly Ammoniacal.	..				
	Fungi	Nil	Nil	Nil	Nil	Nil	Nil	..				
	Insects	Nil	Nil	Nil	Nil	Nil	Present.	..				
	Moisture (Per cent).	23·10	..	..	..	..	..	..				
	Acid Insol. Ash (Per cent N.D.B.)	3·85	..	..	..	..	..	..				
	Sod. Chloride (Per cent N.D.B.)	1·433	..	..	..	..	..	..				
	T.V.B.N.(mgm./100 gm.)	105·0	..	..	150·5	175·0	258·0	..				
	Breakage (gm./100 gm.)	5·5	5·6	6·1	6·0	6·4	6·15	..				
3	Appearance	Good.	Good.	Good.	Fair.	Poor.	..	..	Unfit for Human consumption.			
	Texture	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Slightly soft.	..	..				
	Flavour	Good.	Good.	Good.	Fair.	Poor.	..	..				
	Odour	Good.	Good.	Faintly Ammoniacal.	Faintly Ammoniacal.	Ammoniacal.	..	..				

	Fungi	Nil	Nil	Nil	Present.	Considerable.	..	..	..	..	..	
	Insects	Nil	Nil	Nil	Nil	Present	..	..	..	..	..	
	Moisture (Per cent)	20·40	..	..	..	..	..	..	..	..	..	
	Acid Insol. Ash (Per cent on D.B.)	1·63	..	..	..	..	..	..	..	..	..	
	Sod. Chloride (Per cent on D.B.)	1·813	..	..	..	..	..	..	..	..	..	
	T.V.B.N. (mgm/100 gm.)	94·5	..	..	133·0	182·0	..	..	..	..	..	
	Breakage (gm./100 gm.)	0·95	0·90	1·0	1·95	2·1						
4	Appearance	Good.	Good.	Good.	Good.	Fair.	Poor.	..	..	..	..	Unfit for Human consumption.
	Texture	Hard.	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	..	..	..	..	
	Flavour	Good.	Good.	Good.	Good.	Good.	Fair	..	..	..	..	
	Odour	Good	Good.	Good.	Good.	Faintly Ammoniacal.	Strongly Ammoniacal.					
	Fungi	Nil	Nil	Nil	Nil	Nil	Nil	..	..	..	..	
	Insects	Nil	Nil	Nil	Nil	Nil	Nil	..	..	..	..	
	Moisture (Per cent)	17·80	..	..	..	..	..	..	..	..	..	
	Acid Insol. Ash (Per cent on D.B.)	3·87	..	..	..	..	..	..	..	..	..	
	Sod. Chloride (Per cent on D.B.)	1·463	..	..	..	..	..	..	..	..	..	
	T.V.B.N. (mgm/100 gm.)	112·0	..	..	123·0	140·0	217·0	..	..	..	..	
	Breakage (gm/100 gm.)	6·2	5·8	6·6	5·6	6·1	6·6					
5	Appearance	Good.	Good.	Good.	Fair.	Fair.	Fair.	Fair to poor.	Poor.	..	..	Unfit for Human consumption.
	Texture	Hard.	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	..	..	
	Flavour	Good.	Good.	Good.	Fair.	Fair.	Fair.	Fair to poor.	Poor.	..	..	
	Odour	Good.	Good.	Good.	Slightly Ammoniacal.	Ammoniacal.	Ammoniacal.	Strongly Ammoniacal.	Strongly Ammoniacal.	..	..	
	Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Present.	..	..	
	Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	..	..	
	Moisture (Per cent)	14·96	..	..	..	..	..	..	..	..	..	
	Acid Insol. Ash (Per cent on D.B.)	2·61	..	..	..	..	..	..	..	..	..	
	Sod. Chloride (Per cent on D.B.)	1·430	..	..	..	..	..	..	..	..		
	T.V.B.N. (mgm/100 gm.)	52·5	..	..	110·0	162·0	..	205·0	280·0	..	..	
	Breakage (gm./100 gm.)	0·8	0·80	0·90	0·90	1·0	1·2	1·2	1·5			
6	Appearance	Good.	Good.	Good.	Good.	Good.	Fair	Fair to poor.	Poor	..	..	Unfit for Human consumption.
	Texture	Hard.	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	..	..	
	Flavour	Good.	Good.	Good.	Fair.	Fair.	Fair.	Poor.	Poor.	..	..	
	Odour	Good.	Good.	Good.	Slightly ammoniacal.	Slightly ammoniacal.	Ammoniacal.	Strongly ammoniacal.	Putrid.			

Table I—*Showing Results of Storage Studies on White Bait dried to different moisture levels*—cont.

(*N.B.*—Unfit for human consumption).

ATMOSPHERIC CONDITIONS DURING DRYING.

Serial number of sample. (1)	*Duration of drying (number of hours).* (2)		*Days of drying.* (3)	*First* (4)	*Second* (5)	*Third* (6)	*Fourth.* (7)	*Fifth* (8)	*Sixth* (9)	*Seventh* (10)	*Eighth.* (11)	*Ninth* (12)	*Tenth.* (13)
6	16	R.H. (Percent)	78·0	77·0	..	..	..	..	..	..	..	..	..
		Max. Temp. (° C).	..	30·0	32·0	..	..	..	..	..	..	..	..
		Min. Temp. (° C)	..	24·1	23·8	..	..	..	..	..	..	..	..
7	16	R.H. (Per cent)	..	85·0	82·0	..	..	..	..	..	..	..	..
		Max. Temp (°C)	..	28·2	28·8	..	..	..	..	..	..	..	..
		Min. Temp. (° C)	..	23·0	23·6	..	..	..	..	..	..	..	..
8	24	R.H. (Per cent)	..	85·0	8·20	86·0	..	..	..	..	..	..	..
		Max. Temp. (° C)	..	28·2	28·8	30·1	..	..	..	..	..	..	..
		Min. Temp. (° C)	..	23.0	23·0	24·1	..	..	..	..	..	..	..

9	30	R.H. (Per cent)	85·0	82·0	86·0	78·0	..	..	..	..	..	..
		Max. Temp. (° C)	28·2	28·8	30·1	30·1	..	..	..	..	..	..
		Min. Temp. (° C)	23·0	23·6	24·1	23·5	..	..	..	..	..	..
10	35	R.H. (Per cent)	85·0	82·0	86·0	78·0	66·0	..	..	..	..	..
		Max. Temp. (° C).	28·2	28·8	30·1	30·1	30·0	..	..	..	..	..
		Min. Temp. (° C)	23·0	23·6	24·1	23·5	25·1	..	..	..	..	..
11	42	R.H. (Per cent)	85·0	82·0	86·0	78·0	66·0	77·0	..	..	..	..
		Max. Temp. (° C)	28·2	28·8	30·1	30·1	30·0	31·8	..	..	..	..
		Min. Temp. (° C)	23·0	23·6	24·1	23·5	25·1	26·6	..	..	..	..
12	48	R.H. (Per cent)	85·0	82·0	86·0	78·0	66·0	77·0	98·0	..	..	..

TABLE I—*Showing Results of Storage Studies on White Bait dried to Different Moisture Levels*—cont.

ATMOSPHERIC CONDITIONS DURING DRYING.

Serial number of sample.	*Duration of drying (number of hours).*	*Period of Storage (Number of weeks.*										
		0	2	4	6	8	10	12	14	16	18	20
(1)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
6	Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Unfit for human consumption).		
	Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil			
	Moisture (per cent)	14·21	..	..	..	..	..	..	..			
	Acid Insol. Ash (per cent on D.B.)	3·09	..	..	..	..	..	..	..			
	Sod. Chloride (per cent on D·B.)	1·581	..	..	..	..	..	..	..			
	T.V.B.N. (mgm./100 gm.)	77·0	..	..	120·0	140·0	..	245·0	269·0			
	Breakage (gm./100 gm.)	3·8	3·6	4·0	4·5	4·9	4·8	5·3	5·25	..		
7	Appearance	Good.	Good.	Good.	Good.	Good.	Good.	Fair.	Fair to poor.	Poor	Unfit for humans consumption.	
	Texture	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.		
	Flavour	Good.	Good	Good.	Good.	Fair.	Fair.	Fair	Fair.	Fair.		
	Odour	Do.	Do.	Do.	Slightly ammoniacal.	Ammoniacal.	Ammoniacal.	Strongly ammoniacal.	Strongly ammoniacal.	Strongly ammoniacal.		
	Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
	Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil		
	Mositure (per cent)	12·83	..	..	..	..	..	..	..	..		
	Acid Insol. Ash (per cent on D.B.)	2·45	..	..	..	..	..	..	..	..		
	Sod. Chloride (per cent on D.B.)	1·680	..	..	..	..	..	..	..	..		
	T.V.B.N. (mgm./100 gm.)	84·0	..	..	..	..	..	..	..	..		
	Breakage (gm. /100 gm.)	1·4	1·35	1·90	1·90	1·95	2·90	2·80	3·45	3·90		
8	Appearance	Good.	Good.	Fair.	Fair	Fair.	Fair.	Fair to poor.	Poor.	Very Poor.	Very poor.	Unfit for humans consumption.
	Texture	Hard	Medium hard	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Slightly soft.	
	Flavour	Good.	Good.	Good.	Good.	Good.	Good.	Fair.	Fair.	Fair to Poor	poor.	
	Odour	Do.	Do.	Do.	Slightly ammoniacal.	Slightly ammoniacal.	Slightly ammoniacal.	Ammoniacal.	Ammoniacal.	Strongly ammoniacal.	Strongly ammoniacal.	
	Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
	Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
	Moisture (per cent)	10·63	..	..	..	..	..	..	..	..	..	
	Acid Insol. Ash (per cent on D.B.)	2·51	..	..	..	..	..	..	..	..	..	
	Sod. Chloride (per cent on D.B.)	1·667	..	..	..	..	..	..	..	..	..	
	T.V.B.N. (mgm./100 gm.)	77·0	..	..	118·0	122·5	..	140·0	168·0	210·0	224·0	
	Breakage (gm./100 gm.)	Nil	0·3	Nil	Nil	0·40	0·95	1·20	1·80	1·90	1·90	

9. Appearance	Good.	Good.	Good.	Fair.	Fair.	Fair.	Fair.	Fair.	Fair to poor.	Poor.	Unfit for human consumption.
Texture	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	
Flavour	Good.	Good.	Good.	Fair.	Fair.	Fair.	Fair.	Fair to poor.	Poor.	Very poor.	
Odour	Do.	Do.	Do.	Slightly ammoniacal.	Slightly ammoniacal.	Slightly ammoniacal.	Ammoniacal.	Ammoniacal.	Strongly ammoniacal.	Strongly ammoniacal.	
Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Moisture (per cent)	10·10	..	..	..	..	..	..	..	..	..	
Acid Insol. Ash (per cent on D.B.)	2·56	..	..	..	..	..	..	..	..	..	
Sod. Chloride (per cent on D.B.)	1·670	..	..	..	..	..	..	..	..	..	
T.V.B.N. (mgm./100 gm.)	105·0	..	..	120·0	122·5	..	140·0	..	175·0	210·0	
Breakage (gm./100 gm.)	0·40	0·30	0·50	0·20	0·30	0·25	0·20	0·90	1·03	1·25	
10. Appearance	Good.	Good.	Good.	Good.	Fair.	Fair.	Fair.	Fair.	Fair.	Poor.	Unfit for human consumption
Texture	Hard.	Hard.	Hard.	Hard.	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Slightly soft.	
Flavour	Good.	Good.	Good.	Good.	Good.	Good.	Good.	Fair.	Fair to poor.	Poor.	
Odour	Do.	Do.	Do.	Slightly ammoniacal.	Slightly ammoniacal.	Slightly ammoniacal.	Slightly ammoniacal	Ammoniacal.	Ammoniacal.	Strongly ammoniacal.	
Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Moisture (per cent)	9·83	..	..	..	..	..	..	..	..	..	
Acid Insol. ash (per cent on D.B.)	2·42	..	..	..	..	..	..	..	..	..	
Sod. Chloride (per cent on D.B.)	1·726	..	..	..	..	..	..	..	..	..	
T.V.B.N. (mgm.gm.]	87·5	..	..	98·0	105·0	..	122·5	133·0	140·0	273·0	
Breakage (gm./100 gm.)	0·50	0·65	0·92	1·05	1·15	1·10	1·05	1·20	1·43	2·0	
11. Appearance	Good.	Good.	Good.	Good.	Fair.	Fair.	Fair.	Fair.	Poor.	Poor.	Unfit for human consumption.
Texture	Hard.	Hard.	Hard.	Hard.	Medium hard.	Medium hard.	Medium hard.	Medium hard.	Hard.	Hard.	
Flavour	Good.	Good.	Good.	Good.	Good.	Good.	Fair.	Fair.	Fair to poor.	Poor.	
Odour	Do.	Do.	Do.	Do.	Slightly ammoniacal.	Slightly ammoniacal.	Slightly ammoniacal.	Ammoniacal.	Ammoniacal.	Ammoniacal.	
Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	
Moisture (per cent)	7·23	..	..	..	..	..	..	..	..	..	
Acid Insol. Ash (per cent on D.B.)	2·94	..	..	..	..	..	..	..	..	..	
Sod. Chloride (per cent on D.B.)	1·756	..	..	..	..	..	..	..	..	..	
T.V.B.N. (mgm. 100 gm.)	98·0	..	..	..	..	..	..	..	..	..	
Breakage (gm./100 gm.)	0·80	0·85	1·00	0·93	1·00	1·00	1·10	1·40	1·43	2·20	

TABLE I—*Showing Results of Storage Studies on White Bait dried to Different Moisture Levels*—cont.
(*N.B.*—Unfit for human consumption.)
ATMOSPHERIC CONDITIONS DURING DRYING.

Serial number of sample. (1)	*Duration of drying number of hours.* (2)	*Days of drying* (3)	*First* (4)	*Second* (5)	*Third* (6)	*Fourth* (7)	*Fifth* (8)	*Sixth* (9)	*Seventh* (10)	*Eighth* (11)	*Ninth* (12)	*Tenth* (13)
		Max. Temp. (° C) ..	28·2	28·8	30·1	30·1	30·0	31·8	31·1	..	..	..
		Min. Temp. (° C) ..	23·0	23·6	24·1	23·5	25·1	26·6	25·1	..	..	..
		R.H. (per cent) ..	85·0	82·0	86·0	78·0	66·0	77·0	98·0	62·0	64·0	85·0
		Max. Temp. (° C) ..	28·2	28·8	30·1	30·1	30·0	31·8	31·1	31·0	30·0	31·8
		Min. Temp. (° C) ..	23·0	23·6	24·1	23·5	25·1	26·6	25·1	24·6	24·3	21·7

12. Appearance	Fair.	Fair.	Fair.	Fair.	Fair.	Fair to poor.	Poor.	Very poor.	Very poor.	Very poor.	..
Texture	Hard.	Hard.	Hard.	Hard.	Hard.	Medium hard.	Medium hard.	Hard.	Hard.	Hard.	..
Flavour	Good.	Good.	Good.	Good.	Good.	Good.	Fair.	Fair.	Poor.	Poor.	
Odour	Do.	Do.	Do.	Do.	Faintly ammoniacal.	Slightly ammonical.	Slightly ammoniacal.	Ammoniacal.	Ammoniacal.	Strongly Ammoniacal.	
Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Moisture (per cent)	6·90	..	..	..	..	..	..	..	..	..	..
Acid Insol. Ash (per cent on D.B.)	2·63	..	..	..	..	..	..	..	..	..	..
Sod. Chloride (per cent on D.B.)	1·61	..	..	..	..	..	..	..	..	..	..
T.V.B.N. (mgm/100 gm)	66·5	..	..	70·0	87·5	..	105·0	161·0	187·5	205·0	..
Breakage (gm. 100 gm.)	2·80	2·90	2·90	2·30	2·30	2·50	2·70	3·70	3·45	3·50	..
13. Appearance	Fair.	Fair.	Fair.	Fair.	Fair.	Fair.	Fair to poor.	Very poor.	Very poor.	..	..
Texture	Hard.	Hard.	Hard.	Hard.	Hard.	Medium hard.	Medium hard.	Hard.	Hard.	..	..
Flavour	Good.	Good.	Good.	Good.	Good.	Good.	Fair.	Poor.	Poor.	..	..
Odour	Do.	Do.	Do.	Do.	Do.	Slightly ammoniacal.	Slightly ammoniacal.	Ammoniacal.	Strongly ammoniacal.	..	..
Fungi	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	..	Nil
Insects	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	..	Nil
Moisture (per cent)	6·81	..	..	..	..	..	..	..	..	..	..
Acid Insol. Ash (per cent on D.B.)	2·59	..	..	..	..	..	..	..	..	..	..
Sod. Chloride (per cent on D.B.)	1·67	..	..	..	..	..	..	..	..	..	..
T.V.B.N. (mgm. 100 gm.)	91·0	..	..	90·0	105·0	..	140·0	196·0	212·5	..	..
Breakage (gm. 100 gm.)	1·90	1·90	2·0	2·05	2·20	2·50	2·70	3·10	3·35	..	..

TABLE II—*Showing breakage in Sundriod white baite during processing.*

by weight of broken pieces.

Lot Number.	*At landing centre.*	*Unloaded at the drying ground.*	*At the end of the first day's drying.*	*At the end of the second day's drying.*
(1)	(2)	(3)	(4)	(5)
1.	0·32	1·71	2·13	8·12
2.	0·32	3·04	3·37	3·30
3.	0.32	0.33	7·95	7·13

A NOTE ON THE USE OF SODIUM BENZOATE AND SODIUM BICARBONATE IN THE PREPARATION OF DRIED SALTED FISH

BY

JOSEPH, K. C. AND SRINIVASAN, R., FISHERIES TECHNOLOGICAL STATION, MADRAS STATE.

Introduction.—An exhaustive review of the literature on chemical preservation of fish was recently made by Tarr (1961). In India the use of vinegar in the preparation of fish pickles is well known. Nicholson (1930) found the addition of 1 part of acetic acid to 250 parts of boric acid helpful to improve the preservative action of boric acid on fish. Suryanarayana Rao and Valsan (1962) found propionic acid useful in controlling mould growth and reddening in dried salted mackerel. Jarvis (1950) reported the effectiveness of a mixture of sodium benzoate and sodium acid phosphate in controlling the growth of red halophiles. Sen et al (1961) tried the effect of a mixture of common salt, sodium benzoate and sodium acid phosphate in the preparation of dried salted mackerels. Some experiments were conducted at the Fisheries Technological Station, Cape Comorin on the possible use of a mixture of common salt, sodium benzoate and sodium bicarbonate for the preparation of dried salted *Sardinella Sp. Lactarius Sp.* and *Dussumieria Sp.* The results are presented in the present communication.

Material and methods.—Freshly caught fish of *Sardinella Sp., Lactarius Sp.* and *Dussumieria Sp.* were gutted by opening the ventral sides and washed clean. These were then salted with a mixture containing crushed common salt, sodium benzoate and sodium bicarbonate in the proportion of 100 : 1 : 3 by weight. The ratio by weight of the above mixture to the dressed fish was arbitrarily fixed as 1:7 for *Sardinella Sp.*, 1 : 4 for *Lactarius Sp.* and 1 : 6 for *Dussumieria Sp.* The salted samples were then allowed to remain overnight in contact with the self brine formed during this time, the period under cure being 18 hours for each set of samples. The salt cured samples were then washed in the self brine, and dried in the sun on three consecutive days. Control samples were simultaneously prepared using the same raw material and using common salt only in place of the common salt-sodium benzoate—sodium bicarbonate mixture. The final products were stored in glass jars with lids and the progress of spoilage in each sample assessed periodically for a total period of 180 days in each case. Moisture was determined as per the methods of analysis of the Association of Official Agricultural Chemists (A.O.A.C. 1955). The micro-diffusion method of analysis of Conway as adopted by Beatty and Gibbons (1937) was employed for the determination of T.V.B. and T.M.A. nitrogen. The products were organoleptically rated according to the numerical scoring system of Venkataraman and Vasavan (1956).

Results and Conclusions.—The results of the storage studies conducted with the samples are shown in Tables I, II and III in Annexure for *Sardinella Sp.*, *Lactarius Sp.* and *Dussumieria Sp.* respectively. In all the experiments the self brine resulting from the cure using the mixture of common salt, sodium benzoate and sodium bicarbonate was found to be slightly acidic when tested with litmus at the end of the curing period of 18 hours ; the self brine from the cure using common salt only was found faintly alkaline to litmus. The slightly acid medium appears to have had a beneficial effect on the quality of the cured product. The products prepared with the common salt-sodium benzoate-sodium bicarbonate mixture scored a higher test score based on organoleptic assessment than the control samples prepared with common salt alone. The former were superior to the latter in most of the organoleptically assessed qualities, especially in appearance and texture. As will be seen from the tables the values for TVBN in the experimental samples were always slightly lower than in the control samples. The use of sodium bicarbonate made the products soft in texture on cooking of the cured fish, the softness approximating to almost that of the fresh fish. Jarvis (1950) found sodium benzoate with sodium acid phosphate effective in preventing spoilage due to red halophiles. In the present investigation red attack or 'pink' was not encountered in any of the samples both 'control' and 'experimental'. Hence the effect of the mixture used in countering red halophite attack could not be assessed.

Acknowledgment.—We are grateful to the Director of Fisheries, Madras for permission to publish this paper.

References.

(1)	(2)
(1) A.O.A.C. (1955)	"Official Methods of Analysis of the Association of Official Agricultural Chemists" Eighth Edition.
(2) Beatty, S. A. and Gibbons, N. E. (1937).	Journal of the Biological Board of Canada, 3, 770.
(3) Jarvis Norman, D. (1950).	"Curing of Fishery Products" United States Fish and Wild Life Service, Research Report No. 18, 75.
(4) Nicholson, F. A. (1930) ..	"The Preservation and Curing of Fish" Madras Government Publication, 69–97.
(5) Sen. D. P. Visweswariah, K. and Lahiri, N. L. (1961).	"Studies on dry salting and sundrying of mackerel" Food Science 10, (5) 132–138.
(6) Suryanarayana Rao, S. V. and Valsan, A. P. (1962).	"Control of mould growth and reddening in salted and dried mackerel". Research and Industry, 7 (*a*) 304–3–8.
(7) Tarr, H. L. A. (1961) ..	"Chemical Control of Micro-biological Detorioration" Chapter 17 of "Fish as Food" Vol. I by George Borgstrom., Academic Press, New York, 639–680.
(8) Venkataraman, R. and Vasavan, A. G. (1956).	"Salt curing of Marine Fishes of the West coast (Madras State)" Madras Fisheries Station Reports and Year Book 1954–55, 391–416.

Table I showing the results of storage studies of cured sardinella sp.

Period of storage.	*Experiment number.*	I		II		*Remarks.*
	Samples.	*A*	*B*	*A*	*B*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
30 days	Moisture (per cent)	40·21	40·68	39·13	39·96	(A) Control sample using common salt only.
	T.V.B.N. (mgm./cent)	107·5	92·5	113·0	95·0	
	T.M.A.N. (mgm./cent)	25·0	20·5	23·0	18·0	
	Organoleptic test score (Max. 30).	29·0	30·0	29·0	30·0	(B) Experimental sample using a mixture of common salt, sodium benzoate and sodium bicarbonate.
60 days	Moisture (per cent)	40·16	41·00	39·19	39·54	
	T.V.B.N. (mgm./cent)	154·0	115·0	159·0	109·0	
	T.M.A.N. (mgm./cent)	37·0	31·5	25·5	19·0	
	Organoleptic test score (Max. 30).	27·5	29·0	28·0	29·0	
120 days	Moisture (per cent)	40·14	40·91	39·15	39·38	
	T.V.B.N. (mgm./cent)	214·0	150·5	203·0	146·0	
	T.M.A.N. (mgm./cent)	43·0	37·5	33·0	26·5	
	Organoleptic test score(Max. 30).	25·0	27·0	25·0	27·0	
150 days	Moisture (per cent)	39·28	40·04	39·02	38·95	
	T.V.B.N. (mgm./cent)	227·0	165·0	221·0	155·0	
	T.M.A.N. (mgm./cent)	43·5	39·0	37·5	30·0	
	Organoleptic test score (Max. 30).	24·0	26·0	23·0	26·0	
180 days	Moisture (per cent)	39·87	39·61	39·24	39·12	
	T.V.B.N. (mgm./cent)	311·0	206·0	286·0	212·0	
	T.M.A.N. (mgm./cent)	59·0	52·0	54·0	42·5	
	Organoleptic test score (Max. 30).	20·0	25·0	21·0	24·0	

Table II showing the results of storage studies of cured lactarius sp.

Period of storage.	30 days.		60 days.		90 days.		120 days.		150 days.		180 days.		*Remarks.*
Samples.	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Moisture (per cent)	37·36	38·04	37·34	37·98	37·12	39·83	38·18	38·94	38·69	38·72	38·68	38·76	(A) Control sample using common salt only.
T.V.B.N. (mgm./cent)	120·0	100·0	145·0	132·0	171·0	162·0	262·0	250·0	383·0	377·5	420·5	398·5	(B) Experimental sample using a mixture of common salt—sodium Benzoate and sodium bicarbonate.
T.M.A.N. (mgm./cent)	27·5	25·0	38·0	35·0	40·0	37·5	55·0	53·5	95·0	85·5	107·0	108·0	
Organoleptic test score (max. 30).	29·0	30·0	26·0	29·0	22·0	26·0	18·0	23·0	16·0	21·0	12·0	17·0	

Table III showing the results of storage studies of cured dussumieria sp.

Period of storage.	30 days.		60 days.		90 days.		120 days.		150 days.		180 days.		*Remarks.*
Samples.	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Moisture (per cent)	36·01	37·72	36·18	37·61	36·28	37·60	36·30	37·52	37·09	37·61	37·08	37·63	(A) Control sample using common salt only.
T.V.B.N. (mgm./cent)	87·5	80·0	112·0	100·0	163·0	160·0	271·0	260·0	375·0	306·0	398·0	383·5	(B) Experimental Sample using a mixture of common salt—sodium benzoate and sodium bicarbonate.
T.M.A.N. (mgm./cent)	21·0	20·0	27·5	25·0	44·0	42·0	62·0	57·5	47·0	75·5	106·5	105·0	
Organoleptic test score (maxi. 30).	30·0	39·0	28·0	29·0	23·0	28·0	20·0	25·0	18·0	22·0	12·0	16·0	

SOME STUDIES ON THE PROCESSING AND UTILIZATION OF SEA-WEEDS OF MADRAS STATE

BY

SRINIVASAN, R. AND SANTHANARAJ, T., FISHERIES TECHNOLOGICAL STATION, TUTICORIN.

Sea-weed Resources of Madras State.

Indian resources of sea-weeds, though not considerably large, are sufficiently valuable. In Madras State, there are extensive beds of sea-weeds along the rocky coasts of Thanjavur, Ramanatha- puram and Tirunelveli districts—a distance of about 480 kilometres from Point Calimere to Cape Comorin. As many as 134 species were provisionally listed from the neighbourhood of Krusadai island in the Gulf of Mannar by Chacko, Mahadevan and Ganesan (1955). The weeds of importance that occur in relatively larger quantities are the brown algae *Sargassum Turbinaria*, *Cystophyllum*, *Harmophysa* and *Padina* the red algae *Gracillaria*, *Gelidium*, *Hypnea* and *Sarconema* and the green algae *Chaetomorpha*, *Enteromorpha*, *Ulva* and *Caulerpa*. No precise statistics is yet available regarding the quantity of each species of sea-weed available in the State, though some attempts have been made in this direction. Chidambaram and Unni (1947) estimated the total quantity of sea-weeds washed ashore in the 3 Fish Curing yards in Sethuvbavachatram (Thanjavur district), Idinthakarai and Ovari (Tirunelveli district) as 120 tons in a year. According to Thivy (1952) about 100 tons of agarophytes (red sea-weeds) are available every year in the Pamban area for harvesting, and Pillay and Chacko (1955) have put the figure as 75 tons for brown algae in the Krusadai and Rameswaram islands. Chacko and Pillay (1958) have further estimated an annual yield of 6,000 tons of agarophytes and 60,000 tons of brown algae for the entire coastline from Point Calimere to Cape-Comorin. Prasanna Varma and Krishna Rao(1962) recently conducted a systematic survey of the algae resources along the Pamban area from Dhanushkodi to Hare island in the Gulf of Mannar and found that the economically—important algae were confined to shallow regions generally to depths less than 2—3 meters and along the coral beds or on the rocky substratum covered with a thin layer of sand or clay. Practically none of the weeds was found deeper than 7 meters. According to them, in the Pamban area surveyed by them in 1962–63, 334·90 tonnes of harvestable wet-*Gracillarias*, 18·88 tonnes of harvestable wet Gelidium *micropterum* and 657·94 tonnes of harvestable wet brown algae were found. It was also further observed by them that on an average the red algae (*Gelidium micropetrum* and *Gracillaria spp.*) attained harvestable size in about 2–3 years while the brown algae (Sargassum, Turbinaries (*Cystophyllum muricaterum*) took about 4 years. It has been roughly estimated by the authors that about 80 tons of wet sea-weeds Gracillaria sp. are drifted and washed ashore along the Madras State Coast annually to yield about 10 tonnes of dried weeds.

Present Methods of Collection and Utilisation.

The present methods of collection of sea-weeds in the State are mainly by manual picking of the drift weeds all along the shore. Occasionally they are also manually harvested form the shallow coastal areas. After washing in sea water they are generally sundried on the beach and stored in we ventilated rooms.

The sea-weeds are not yet popular in our country as a direct food, though from time immemorial, they are consumed in the raw, dried or cooked condition by the people of Coastal China, Hawaii, Indonesia, Japan, Korea, Malaya and other countries of the Indo-Pacific region. With a view to popularise the use of sea-weeds as direct food in Madras State, some culinary experiments were conducted at the Marine Biological Station, Krusadai island by Chacko and Malu Pillay (1958 loc. cited), who found that a variety of dishes could be prepared with the sea-weeds.

Sea-weeds are also at present used as manure to some extent in the Coastal tracts of Madras State, being rich in potassium sulphate and trace elements. Chidambaram and Unni (1947 loc. cited) composted sea-weed manure in Krusadai island with *Sargassum Turbinaria* and *Gracillaria* in the proportion of 5 : 3 : 3. They were mixed with offal and Shark Liver oil sediment in the porportion of 15 : 3 : 4 and covered in a pit of 4 feet cube with palmyra and casuarina leaves and sand piled over the pit. The manure was formed in about 12 weeks and had 2·37 per cent Nitrogen 3·47 per cent Potash and 0·66 per cent Phosphoric acid. Trials conducted with sea-weed compost at the Coconut nursery, Pamban during the years 1962–63 and 1963–64 have shown that—

(1) Preparing compost by heapsystem improves quality both physically and chemically.

(2) Washing of sea-weeds prior to composting is necessary to improve the quality.

(3) The decomposition of raw materials and the ripening of compost is completed within 80 days. There is no advantage in prolonging the period of composting beyond 80 days, and

(4) The quality of sea-weed compost is found to be the best after washing and preparing in heaps for 80 days.

The results of analysis of a typical sea-weed compost manure prepared by the State Fisheries Department at the Rameswaram Manure Centre are as follows :—

	PER CENT.
(1)	(2)
Moisture	14·62
Insolubles	11·35
Nitrogen-N(Total).	1·58
Phosphoric acid P_2O_5 (Total)	0·60
Potash K_2O	0·73
Lime CaO	10·78

The chemical composition of the sea-weed compost manure shows that as a basal dressing and in combination with synthetic fertilisers in quantities depending upon the specific crop requirements, the sea-weed compost manure has great potentialities in making the coastal tracts of the State more productive.

Studies have been conducted at the Fisheries Technological Station, Tuticorin during the past 3 years on better and more profitable methods of utilisation of the two commercially important varieties of sea-weeds in the State namely the red algae *Gracillaria spp.* and the Brown algae Sargassum spp. for production of good adjuncts and industrial products like Agar, Alginic acid and Sodium alginate. These investigations and the results so far achieved are presented in this paper.

Agar-Agar.

The most common Agarophytes occurring in the coastal districts of Ramanathapuram, Tirunelveli and Thanjavur in Madras State are *Gracillaria spp.* and *Gelidium micropterum* which have been found to be valuable raw materials for the production of Agar-Agar by Bose et. al. (1943) Karunakar et. al. (1943), Chackraborthy (1945), Thivy (1952), Mohanty (1956) and Chacko and Malu Pillai (1958) who employed different processes for the extraction of Agar. Thivy (1958) also worked out a cottage industry method of manufacturing Bacteriological agar from *Gracillaria spp.* Kappanna and Visweswara Rao (1963) studied the effect of different treatments of Gracillaria and Gelidium on the quality of the Agar produced and standardised the conditions for the production of good quality agar. A series of experiments were also made at the Fisheries Technological Station, Tuticorin with a view to standardise the process of extraction of agar from the sea-weed *Gracillaria spp.* and to prepare a process flow chart for the commercial utilization of the large quantities of the sea-weed occurring in the State to manufacture Agar-agar on a pilot plant scale. The details and results of the experiments are given in Annexure I, which shows the yield of Agar in each experiment, the gel strength, setting temperature, melting point, moisture, ash, acid insolubles, nitrogen, Calcium and sulphate contents of the agar samples obtained in the various experiments. The properties and composition of the commercial samples of Japanese and Difco Agar also are shown in this annexure for comparison. The gel strength, setting temperature and melting temperature were determined with 1·5 per cent agar solution as recommended by Wood (1946).

Based on the results of these experiments, the following standard process has been suggested by Srinivasan and Santhanaraj (1967 loc. cited) for the commercial production of Agar-agar from *Gracillaria spp.* for setting up small agar plant of 3 tons annual capacity in Madras State.

The red sea-weeds Gracillaria spp. are washed well in sea water and sun-dried for 3 days sprinkling sea water daily in the morning. The sea-weeds are then washed well in fresh water several times and sun-dried on mats with repeated sprinking of fresh water until bleached completely and dried and stored in ventilated rooms.

Thirty kg. of the bleached and dried sea-weeds are pulverized into fine powder in a machanical disintegrator. The sea-weed powder is then rinsed in fresh water and then added to about 1,200 litres of boiling water in an open S.S. evaporator, adjusting the pH to 6 by adding about 3 litres N. Sulphuric acid. After boiling for about 4 hours it is filtered hot in S.S. Steam jacketted filter and the filtrate cooled to gel in S.S. Trays. The Agar gel is cut into strips, frozen in ice plant or freezer for 24 hours and then thawed. The strips of Agar thus got are dried in a current of hot air at 50° C in a drier. The dried agar may then be powedered in a mechanical pulvarizer to get about 10 kg. of Agar powder. The agar powder can be packed in polythene bags or tins and sold in the market. By this method it has been found that it is possible to get a consistent yield of 33 per cent (dry weight of the weed) of good quality agar.

The properties of the agar samples produced in the experiments compared very favourably with those of market agar samples. The cost of production worked out to less than Rs. 20 per kg., as compared with the prevailing market rates of Rs. 40 to Rs. 220 perkg. of imported agar. According to the estimates of the authors, about 80 tons of wet sea-weeds Gracillaria spp. are annually landed along the Madras State coast and this will yield as raw material about 10 tons of dried weeds. This will be adequate for the production of about 3 tonnes of agar per annum. The setting up of a small agar plant of about 3 tons capacity/annum in Madras State may thus be a profitable venture besides utilizing the now practically unused sea-weed resources of the State. This may also help to save foreign exchange for the country by restricting the import of agar-agar to this extent.

Alginic acid and Sodium alginate.

The brown weeds *Sargassum spp.* which occur in large quantities off Madras State coast have been found to be good resources of Alginic acid and Sodium alginate by Varrier and Pillai (1952), Valsan (1955) and Chacko and Malu Pillai (1958). Sadhasivam Pillai and Shynamma (1959) estimated about 18 per cent to 24 per cent of Alginic acid in the mixed *Sargassum spp.* available around Cape Comorin. Visweswara Rao and Mody (1965) have reported the optimum conditions for the extraction of Alginic acid from the brown algae occuring on the Saurashtra Coast. Studies have also been made in the Fisheries Technological Station, Tuticorin during the past 3 years on the utilisation of the sea-weeds *Sargassum spp.* available in Madras State for production of Alginic acid and Sodium alginate on a large scale and these studies are reported in the present paper.

The extraction process standardised as a result of our experiments is as follows :—

The Sargassum sea-weeds drifted or harvested is washed in sea-water first and then in fresh water and dried. The dried sea-weed is powdered in a disintegrator. 50 grams of the Sargassum powder is treated with 2 per cent Hydrochloric acid (300 ml.) for 24 hours adjusting the pH to about 3. It is then filtered, washed well free of acid and treated with 3 per cent Sodium Carbonate solution (350 ml.). The contents are stirred well for about 2 hours and kept for reaction for 20 hours. A highly viscous Sodium alginate solution is formed. It is diluted with water, stirred well and then filtered through filter cloth. The filtrate is found to contain finely suspended particles of the sea-weed which are removed to a great extent by centrifuging the filtrate.

The clear sodium Alginate Solution is treated with .2 per cent Hydrochloric acid (400 ml.) adjusting the pH to about 7·0. Then a Sodium Hypochlorite solution is prepared by dissolving 5 gms. of Sodium carbonate and 5 gms. of bleaching powder in 500 c.c. water and filtering to get a clear solution. About 500 c.c. of the Sodium Hypochlorite solution is added till the alginate solution is bleached from the dark brown colour to straw yellow colour. Then 500 c.c. of 5 per cent Hydrochloric acid is added till the pH comes to about 3. The acid is filtered, washed and dried. The alginic acid being Hydrophyllic in nature, it will be difficult to remove the water completely by filtration. The water is removed by boiling with alcohol and squeezing. The alginic acid thus obtained is dried in a current of hot air at a temperature of 50—55°C in trays, taking care not to dry the acid below a moisture content of 15 per cent, as otherwise it may cause certain irreversible changes affecting the hydrophyllic properties of the product.

Different concentrations of Sod. Carbonate solution were tried for the extraction to find out the optimum concentration for maximum extraction. It was found that 2 per cent to 3 per cent Sod. Carbonate solution is enough for the extraction, the maximum yield obtained being about 20 per cent. Increase of the Na_2CO_3 strength beyond 3 per cent did not show any increase in the yield of the product.

Sodium Alginate.

The Sodium alginate can be prepared either by the direct method or by the indirect method through alginic acid.

In the direct method the seaweed after pretreating with acid is extracted with Sodium carbonate and allowed to react for 20 hours. The sodium carbonate extract is diluted, filtered through filter cloth and centrifuged. The sodium Alginate thus obtained is treated with hydrochloric acid adjusting the pH to 7·0 and bleached by Sodium Hypochlorite. The purified Sodium alginate is then evaporated in a hot air oven to get the solid Sodium Alginate.

The following disadvantages were noted in this direct method of Sodium alginate preparation. Since the Sodium alginate solution is too viscous, too much of water has to be added during dilution to facilitate filtration easy. But this implied subsequent evaporation of large quantities of water. The resulting Sodium alginate is also found to be not of good colour probably because of the presence of impurities. Therefore the indirect method of preparing the Sodium alginate through alginic acid was tried and the product produced by this method is found to be of better colour and purity.

In the indirect method, the alginic acid produced by the method described above is not treated with alcohol. About 8 grams of well powdered Sodium Carbonate is added little by little by stirring till a clear liquid is formed with the evolution of carbondioxide. The clear Sodium Alginate solution formed is then evaporated in a hot oven at 55°C. The horny material thus formed is powdered and packed. The yield obtained by this method is 26·0 per cent of the weight of dry seaweed. This was confirmed by repeating the experiment twice.

The viscosity of this Sodium alginate was found out for different strengths like 1 per cent, 2 per cent and 3 per cent solutions and compared with the imported commercial samples with the help of Red wood Viscometer No. 1. The results are shown below:—

Serial number and Sample.	*Viscosity C.P. at 32° c*		
	1 per cent. soln.	*2 per cent. soln.*	*3 per cent. soln.*
(1)	(2)	(3)	(4]
1. Sodium Alginate (Market sample) (Foreign product).	1·40	1·88	3·12
2. Sodium Alginate sample prepared in Fisheries Technological Station, Tuticorin.	1·29	1·77	2·82

It will be seen from the above that the Sodium alginate samples prepared by us by the method described above compared very favourably in appearance and viscosity with the foreign products in the market. The cost of production by this process will work out to about Rs. 40 per Kg. as compared with the prevailing market rates of Rs. 60 to Rs. 120 per Kg.

Conclusion.

There is thus great scope for the profitable utilisation of the sea-weed resources of Madras State. The edible-weeds may be popularised as direct food and as poultry and stock food. The sea-weed compost manure, as a basal dressing and in combination with synthetic fertilizers in quantities depending upon the specific crop requirements has great potentialities in making the coastal tracts of the State more productive. The Red and Brown weeds can be made use of for the commercial production of food adjuncts and products like agar-agar, alginic acid and Sodium Alginate. Production of agar and Sodium Alginate will considerably help to utilize in full the seaweed resources and make available indigenous Agar and Sodium Alginate at relatively cheap rates and save considerable foreign exchange. However, the absence of the precise statistics on the nature and extent of the sea-weed resources all along the Madras State Coast seems to be one of the major obstacles retarding further progress in developing sea-weed based industries in the State. A rapid quantitative survey of the marine algae of the State is therefore of immediate importance. Besides a systematic study of the ecology of the commercially important sea-weeds, steps should also be taken for their culture and farming on a large scale in suitable areas like Pamban in Ramanathapuram District with a view to ensure a steady supply of the weeds for the proposed sea-weed based industries in the State.

Acknowledgments.

We are thankful to the Director of Fisheries, Madras for his permission to submit this paper for the " Symposium on Sea salt and Plants " at Bhavanagar in December 1965 and also to publish this paper.

References.

(1) Bose, J. L., Karimullah and Siddique, S. (1943)—" Manufacture of Agar-in-India ". J. Sci. and Ind. Res. (India) 1:98.

(2) Chacko, P. I., Mahadevan, S. and Ganesan, R. (1955)—" A guide to the field study of the fauna and flora of Krusadai Island Gulf of Mannar ". Contribution from the Marine Biological Station, Krusadai Island, Gulf of Mannar, No. 3, Madras Government Publication.

(3) Chacko, P. I. and Malu Pillai (1958)—" Studies on utilization of the sea-weed resources of Madras State ". Contribution from the Marine Fisheries Biological Station, Krusadai Island, Gulf of Mannar, No. 6. Madras Government Publication, pp. 1–12.

(4) Chakraborty, D. (1945)—" Agar-Agar manufacture from Gracillaria confervoides ". J. Proc. Inst. Chem· (India) 17:188.

(5) Chidambaram, K. and Unni, MM. (1947)—" Notes on the value of sea-weeds as Manure". Madras Agri. Journals and Proc. 1st International sea-weed Symposium, Edinbourough, 1952, 67–68, 1953.

(6) Kappanna, A. N. and Viswesara Rao, A. (1963)— " Preparation and properties of Agar-agar from Indian Sea-weeds " Indian Journal of Technology Vol. I. No. 5. pp. 222–224.

(7) Karunakar, P. D., Raju, M. S. and Varadarajan, S. (1948)—" Manufacture of Agar-agar from sea-weed Gracillaria lichenoides ". Ind. Vet. J. 24, 274.

(8) Mohanty, G. B. (1956)—" Fisheries by-product Industry in India Sea-weeds '—Progress of Fisheries Development in India, Cuttack ".

(9) Pillai, C., Malu and Chacko, P. I. (1955)— "Studies on the seasonal fluctuations of alginic acid and dry matter contents of *Phaeophyceae* around Krusadai Island in the Gulf of Mannar ". Fisheries Station Reports and Year Book 1954–55, Department of Fisheries, Government of Madras, pp. 165–173.

(10) Prasanna Varma, R. and Krishna Rao, K. (1962)—Algae resources of Pamban area ". India. Journ. Fisheries, Vol. IX, No. 1, Section A, pp. 205–211.

(11) Sadhasivan Pillay, K. and (Smt.) Shynamma, C. S. (1959)—" Alginic acid and Mannital from Sargassum sea-weed extraction on small scale industry basis ". Chemical Age of India. Vol. 10, No. 4, pp. 483–492.

(12) Srinivasan, R. and Santhanaraj, T.—" Studies on the Extraction and properties of Agar-agar from the Sea-weed *Gracillaria spp.* in Madras State ". Madras Journal of Fisheries III, 146–151.

(13) Thivy, F. (1952)—" Investigation of sea-weed products in India with a note on some properties of various Indian agars ". Proc. Ind. Pac. Fisheries Council, Sections, II and III, 172–175.

(14) Thivy, F. (1953)—" Economic sea-weeds", Fisheries of the West Coast of India, Bangalore.

(15) Thivy, F. (1961)—" Seaweed Utilization in India ". Proc. of Symposium on Algology, (Indian Council of Agricultural Research, New Delhi, pp. 345–365).

(16) Valsan, A. P. (1955)—" Alginic acid content of some of the common sea-weeds of the Gulf of Mannar area ". Curr. Sci., 24:343.

(17) Varier, N. S. and Pillai, K. S. (1952)—" I. Mannitel from sea-weeds. II. Optimum conditions for the extraction of alginic acid from Sargassum sea-weeds of Cape Comorin ". Bull. Cent. Res. Inst, 2:30.

(18) Visweswara Rao, A. and Mody, I. C. (1965)— " Extraction of Alginic acid and alginates from Brown Sea-weeds". Indian Journal of Technology, Vol. 3., No. 8, pp. 261–262.

(19) Wood, F. E. J. (1946)—" Agar in Australia ". Council of Scientific and Industrial Res. Bull No. 203.

ANNEXURE I.

Showing the yield and properties of Agar obtained in the various experiments.

Experiment number and Method used for extractions.	*Proportion of sea-weed: water used.*	*Yield in per cent.*	*Gel. strength (gms Sq./cm.).*	*Setting temperature (°C)*	*Melting temperature (°C).*	*Moisture per cent.*	*Ash per cent.*	*Acid Insolubles per cent.*	*Nitrogen per cent.*	*Calcium per cent.*	*Sulphate per cent.*
									(On dry basis.)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1 C.M.F.R.S. Method (Thivy 1958, Loc. cited).	1:30	28·0	60·00	40°C	81°C	17·4	11·17	3·5	0·310	1·99	2·400
2 C.M.F.R.S. Method as in Expt.	1:40	15·00	70·00	39°C	80°C	17·00	6·2	1·37	0·060	1·30	2·98
1 but the gel. purified by freezing and thawing.		5·00	100·00	..	..	14·10	5·2	1·10	..	..	..
3 Do. ..	Do.	28·00	65·00	40°C	79°C	17·12	6·7	2·6	0·194	1·38	2·97
		5·5	63·00	..	..	13·00	7·69	3·4	..	..	..
4 Sea-weed after washing, ground to pulp in wet grinder and added to boiling water and boiled for 45 minutes filtered, cooled to gel. frozen, thawed and dried in airoven.	1:30	15·00	121·00	42°C	61°C	17·4	10·92	3·92	0·288	1·977	1·73
	1:15	11·00	65·06	..	..	17·4	11·73	2·34	..	..	..
5 Soaked in water for 4 hours ground to paste in wet grinder, added to boiling water, Sulphuric Acid added to bring pH to 6·0 and boiling continued for 45 minutes, filtered, cooled to gel. frozen, thawed and dried.	1:48	25·5	115·00	42°C	81°C	16·18	10·74	2·63	0·298	1·82	1·78
6 Same as Expt. 5 but second extraction also done.	1:48	23·00	102·00	41°C	81°C	18·58	14·45	5·84	..	1·59	1·74
	1:40	14·00	70·00	..	..	16·25	19·01	7·501	..	..	..
7 Same as Expts. 5 and 6 but the ground pulp soaked for 24 hours and dried before extraction.	Do.	16·00	169·00	39°C	79°C	13·48	13·58	2·89	0·09	1·405	3·4
8 Same as Expts. 7 but no drying of the pulp before extraction.	Do.	21·00	128·00	39°C	81°C	21·9	14·96	1·18	0·119	1·51	3·41
9 Same as Expt. 8 but second extraction done.	Do.	16·00	120·00	..	..	17·3	5·9	0·193	0·32	2·000	3·567
	Do.	8·00	126·00	..	..	16·10	3·4	0·161	..	..	..
10 Sea-weed powdered finely in a laboratory mill before extraction and ground to paste in a wet grinder before extraction as per experiment No. 8,	1:45	33·33	141·00	40°C	79°C	20·6	6·504	1·767	0·305	1·80	2·335
11 Sea-weed well powdered in Laboratory mill and straight away extracted as per Expt. 8.	1:60	37·00	156·00	42°C	79°C	19·72	7·718	1·858	0·298	1·727	3·64

ANNEXURE I—*cont*.

Showing the yield and properties of Agar obtained in the various experiments.

Experiment number and Method used for extractions.	*Proportion of sea-weed water used.*	*Yield in per cent.*	*Gel. strength (gms. Sq./cm·).*	*Settin temparature (°C)*	*Melting temparature (°C)*	*Moisture per cent.*	*Ash per cent.*	*Acid Insoulbles.*	*Nitrogen per cent.*	*Calcium per cent.*	*Sulphate per cent.*
								(On dry basis.)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Commercial Agar Samples.											
(i) Japan Agar (Used for bacteriological work).	..	..	245·00	38°C	85°C	19·06	3·376	0·420	0·15	1·36	3·887
(ii) Bapco agar (Japanese Kappanna and Visweswara Rao (1963, loc. cited).	...	..	75·00	38°C	86°C	17·13	2·28	..	0·16	0·56	1·50
(iii) Difco agar, Kappanna and Visweswara Rao (1962 loc. cited).	..	..	55·00	38°C	89°C	18·91	3·02	..	0·10	0·30	2·02

VARIATIONS IN PROXIMATE AND MINERAL COMPOSITION OF THE MUSCLE OF CROCODILES FROM BHAVANISAGAR RESERVOIR.

BY

A. SREENIVASAN AND R. SOUNDER RAJ.

Data on the composition of certain aquatic animals such as crocodiles is scanty though extensive data is available on fishes[1]. In an earlier note[2], we furnished data on the proximate composition of two crocodiles but no attempt was made to correlate this with the sex, maturity, etc., of the animals. Hence, when more specimen became available further analysis were carried out and the results are furnished here. In view of the non-availability and difficulty of procuring crocodiles at different stages, the present data gives a glimpse of the variations (Table I).

A striking feature is the low hydration and the inversely high fat content of the muscle in the female crocodile having well developed eggs. The iron content was highest at this stage, but calcium was lowest. It is presumed the calcium has been used up in the building up of the developed eggs, that are to be discharged. The fat reserve might serve as a source of energy for spawning activity. During subsequent month water content of muscle increased and fat decreased. Iron also decreased. At this stage, the developed eggs must have been laid. In the spent crocodile muscle, hydration was highest and the protein lowest. Iron content was further reduced. Such a drastic reduction in protein was also noticed by us in spent female of *Labeo fimbriatus* (Sreenivasan, unpubl). In these cases, muscle protein is used up in spawning. Lovern [4] also feels that protein is transferred to maturing gonads and hence the low solids content in spent fish, the analysis of male crocodile shows some differences-lower iron content, higher calcium and phosphorus than the normal female. The mineral content of crocodile muscle is definitely higher than that of the fresh water fishes examined by us [5].

The free amino acids were identified by paper chromatography. In the crocodile of January, Lysine, Taurine, Glycine-serine-aspartic acid, Glutamicacid-threonine. Alanine and Leucine bands were identified in addition to a band below Cystine. In the February specimen, Alanine and Leucine were absent. The unfertilized eggs from this crocodile had Cystine, Glutamic acid-threonine, Alanine and leucine bands. The muscle of male crocodile of April 1963, had Lysine, Taurine, Glycine-serine-aspartic acid, Glutamic acid-threonine and Alanine bands. Variations in the free amino acid content in the muscle of the crocodiles of different maturity stages and of sexes is indicated.

We wish to thank Mr. V. Ranganathan, for furnishing the particulars of sex and maturity of the crocodile.

References.

(1) Love, R. M., Lovern., J.A., and Jones. N. R. (1959) : "The Chemical composition of fish tissues". Food Investigation Special Report No. 69 : HMSO, London.

(2) Sreenivasan, A. & (Mrs.) F. Chandrasekaran (1962), J.S.I.R., 21 C(7) : 192.

(3) Natarajan, M. V. & Sreenivasan, A. (1961) : Indian Jour. Fish., 8 : 422–429.

(4) Lovern., J.A. (1937) : Jour. Mar. Biol. Assoc., (U.K.) 22 : 281–293.

TABLE.

The proximate and mineral composition of crocodile muscle.

Date. (1)	*Sex, maturity and stage.* (2)	*Length.* (3)	*Weight.* (4)	*Moisture.* (5) PER CENT.	*Protein.* (6) PER CENT.	*Fat.* (7) PER CENT.	*Cal.* (8) PER CENT.	*P_2O_5.* (9) 05	*Iron.* (10) MG. PER CENT.
December 1961 ..	Not determined	1·98	..	77·57	16·15	4·33	0·13	0·36	11
January 1963 ..	15 well developed eggs in the Oviduct; 30·40 imature Ova on either side.	2·41	80·0	65·03	16·44	17·95	0·13	1·06	31
February 1963 ..	Oviducts loose, flabby with soft 40 Ova on either side.	1·88	55·0	76·23	19·65	4·04	1·41	0·94	25
March 1963 ..	Spent, Ovary undergone reabsorption. Very few Ova seen. Oviducts Shrunk Eggs laid earlier.	1·88	55·0	80·60	8·5	7·99	0·40	2·1	19
April 1963 ..	Not determined	2·62	65·0	72·80	15·8	11·25	1·21	1·38	15

A NOTE ON THE PROXIMATE COMPOSITION OF TURTLE, TESTUDO ELEGANS.

BY

A. SREENIVASAN AND R. SOUNDER RAJ.

Food value of most of the aquatic animals has been determined and data are available, but data for certain edible less common animals are not recorded. The proximate composition and free amino acids of the crocodile were furnished by Sreenivasan [1]. Turtles, both marine and fresh water, are consumed and in fact in Japan extensive fresh water turtle farms were seen by the author. It was therefore thought desirable to gain some knowledge on the nutritive value of turtles. A female turtle weighing 1·2 kg. was caught in the nets at Bhavanisagar. The edible flesh was taken, minced well and analysed according to standard procedures[2]. The proximate composition is furnished below :—Water 74·56 per cent, Protein 18·32 per cent, Fat 8·4 per cent, Ash 1·23 per cent, P_2O_5. 0·62 per cent, Ca 0·36 per cent and Fe 16 mg. per cent. It is seen that the protein content was similar to that of the crocodile [1] but the fat content was higher and water content less. The phosphorus was similar to that of crocodile but a little more than that of fresh water fishes[2]. While the calcium content was higher than that of crocodile and fishes, iron content was much greater than that of the crocodile and nearly double that of fresh water fishes[2]. Thus the value of the turtle as a good source of protein, fat and minerals is established and our knowledge on the composition of aquatic animals extended.

References.

[1] Sreenivasan, A. and Chandrasekaran, Mrs. F., Jour-Sci Ind. Res. 21C. (7) 192. 1962,

[2] Natarajan, M. V. and Sreenivasan, A. Indian Jou. Fish 8. 422–429 1962.

CLINOMETER

BY

K. A. DORAI RAJAH, WORKS MANAGER, GOVERNMENT BOAT BUILDING YARD, NAGAPATTINAM.

THE CONSTRUCTION, AND USE OF A SIMPLE CLINOMETER DESIGNED AND MADE BY THE AUTHOR IS DESCRIBED IN THIS ARTICLE.

The Clinometer is essentially an instrument for measuring angles relative to the horizontal and vertical planes. There are several types of Clinometers but based only on two basic principles; one involving the use of a spirit level and the other using a pendulum. In the first type the angle relative to the horizontal plane is measured while with the latter the angle relative to the vertical plane is measured. In this article an efficient horizontal type of Clinometer that can be made cheaply is described. With the aid of this gadget the shaft angles, keel inclination, engine bed levels can be quickly checked or measured. Hence it is a very useful instrument for a Boat Yard. In fact there is no other direct method of measuring the keel angle and shaft inclinations, etc.

Principle of the instrument.—The sketch in plate (1) gives an idea of the instrument and the principle involved. The instrument has a rigid frame with a horizontal arm 'A' and a vertical arm 'B' fixed at right angles to each other. 'C' is a movable arm mounted on a hinge to arm 'A' at its free end. The hinged arm 'C' is capable of moving up and down by a clamping screw by which the arm can be set at any desired position.

The arm carries a spirit level and a pointer which moves against a protractor marked on arm 'B'. For measuring angles of inclined surfaces relative to the horizontal, the base of the instrument is made to lie flat on the inclined surface and the movable arm is raised slowly till the spirit level indicates "level". The angle of inclination is directly read by the pointer on the protractor. The photograph shows how the instrument is used.

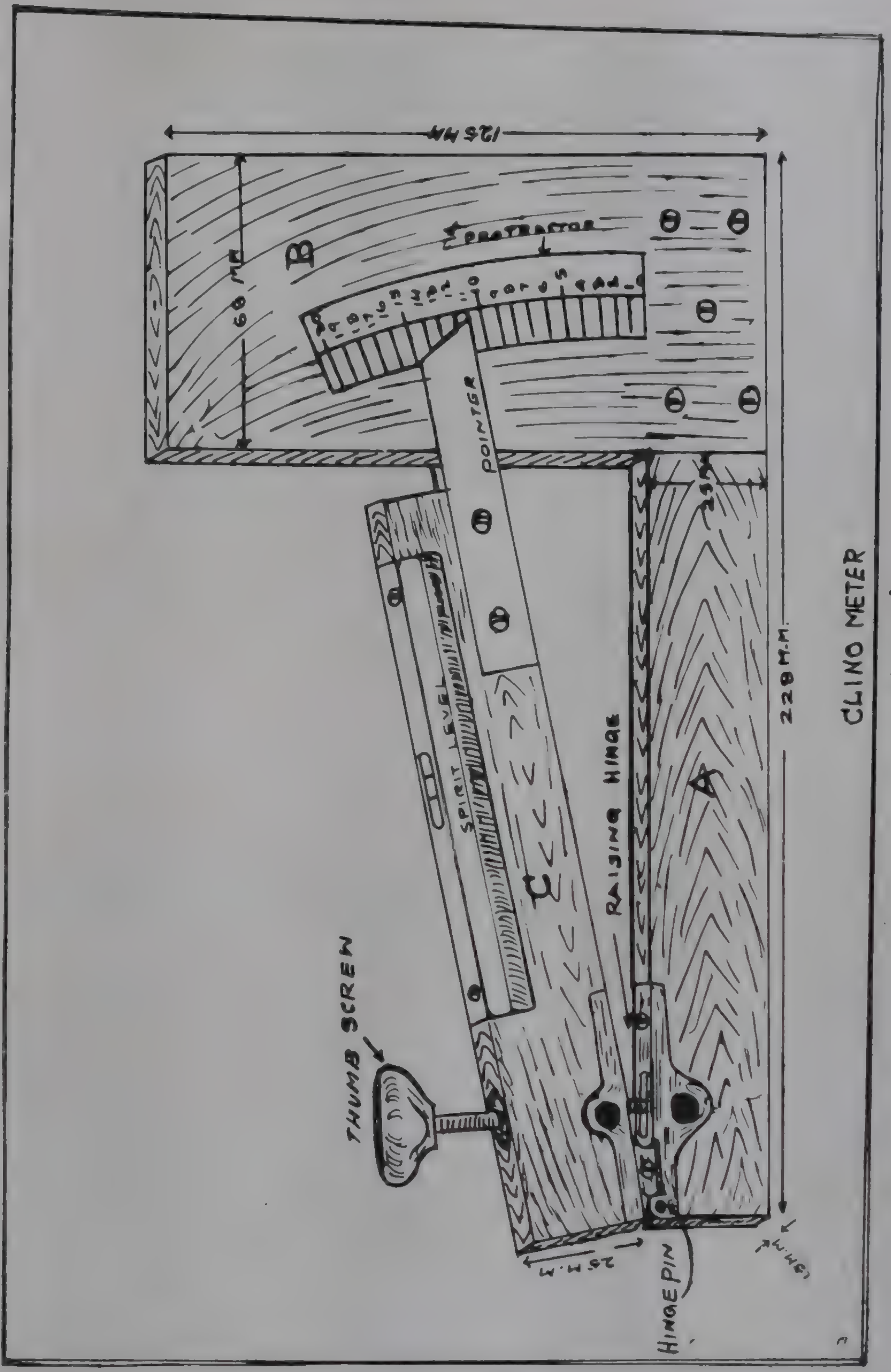
Construction.—The frame is made of Teakwood of ½" thickness (12·5 m.m.). The rigid frame can be made in one piece or in two pieces and joined. The joint should be a perfect right angle. The movable arm should be of the same thickness and height as the horizontal base arm. A spirit level of 100 m.m. length 12 m.m. width and height should be fixed in a groove or recess cut in the movable arm (as shown in the sketch), in such a way that its top face is flush in line with the top of the moving arm. It should be ascertained that when the moving arm is placed over the horizontal base arm and the instrument is laid over a level surface the air bubble of the spirit level is at dead centre and shows level.

Next the movable arm has to be suitably fixed to the base in such a way that the arm can be raised or lowered by a screw. A very handy hinge is one cut out of a regular burette clamp used in the laboratories. The two halves of the hinge are dismantled and separately mounted on to the arms by making suitable recess in the arms and fixing by two screws machines to fit flush and glued with a synthetic adhesive. Care should be taken to see that the fulcrum (or hinge pin) lies exactly in a line with the base line.

Then the thumb screw is worked into the assembly. By a few trials it can be so adjusted that the moving arm can be raised or made to lie flat on the base arm by working on the screw. After adjusting this movement the hinge pin can be fitted to the hinge.

The indicator or pointer is a white celluloid piece fixed to the two sides of the movable arm in such a way that it forms a guide to the sliding arm. The base of the pointer should be accurately in a line with the base line of the arm. A protractor is marked on the vertical arm as shown. The zero mark is in a line with the base of the moving arm as well as the top of the horizontal arm. Before use this instrument should be checked with present angles and inclinations.

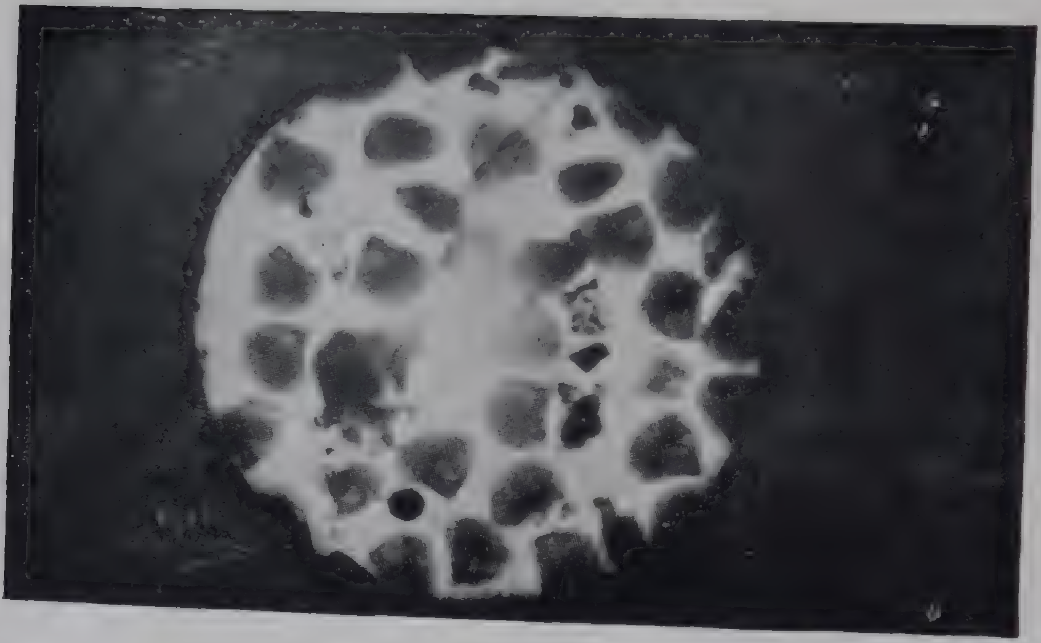
The instrument made by the author personally cost him less than Rs. 5. If the instrument is made carefully it can compare very well with the costly models supplied by the scientific companies.


125 MM
68 MM
B
PROTRACTOR
POINTER
SPIRIT LEVEL
C
RAISING HINGE
A
25 MM
228 M.M.
THUMB SCREW
25 M.M
HINGE PIN
13 M.M

CLINO METER

Plate 1

" THE PHOTOGRAPH SHOWS THE USE OF THE INSTRUMENTS "CLINOMETER".



AN IMPROVISED WOOD WORKING LATHE

BY

K. A. DORAI RAJAH, Works Manager, Boat Building Yard, Nagapattinam.

AMONG THE WOOD WORKING MACHINERY NECESSARY IN A BOAT YARD A WOOD WORKING LATHE IS ONE. IN THE ABSENCE OF A REGULAR LATHE ONE CAN BE IMPROVISED CHEAPLY AS DESCRIBED IN THIS ARTICLE FROM SCRAP MATERIALS.

The lathe that is described here has been made from some scrap and is being worked by the motor of the planning machine. Any motorised machine with a H.P. of 3 to 5 can be used. Or if a separate motor is available well and good.

The wood working lathe.—The lathe (*vide* photograph and sketch) consists of a rigid wooden frame with a seat for the turner and a shelf for him to keep his tools. The fixed stock is held in a vertical post fixed on the left side and the tail stock or the movable stock is made to move in a grooved base opposite to the fixed stock.

Fixed stock.—It is improvised from a discarded journal bearing obtainable from a second hand store (*vide* plate 3). One end of the bearing axle is tappered and flattened by filing to hold the work piece. The other end is grooved to take a key for fitting the driving pulley. The bearing alone is fittled tightly to the fixed post in such a way that the shaft protrudes on either side of the post. That is the thickness of the post should be just equal to the length of the Bearing. The spindle should be horizontal to the base line. A wooden pulley of 4½ inches diameter and 1½ inches thickness with a rope groove of half inch to take the driving rope, is fitted on to the spindle shaft with a tightly driven key.

This pulley is connected by a good driving rope (or leather thong) to a double grooved pulley of 4 inches diameter and 3 inches thickness which clamped by a iron flat with a through bolt fitted through the pulley and the vertical post at its base (*vide* sketch and photo). It is better to provide bush bearing in the pulley and the vertical post to allow free movement of the bolt and the rotation of the pulley. This pulley is connected to the motor drive of 3 to 5 H.P. provided with an extension or vee belt pulley.

Tail stock'(*Vide* plate 2).—This made from a discarded broken 'G' clamp (9 inches to 12 inches clamp) with three-fourth or one inch screw. The nut portion of the clamp is cut and ground smooth. The end of the screw is tapered and sharpened to a dull point to hold the work piece. A wooden stock is made as shown in the sketch and the screw with its nut is fitted to the moving stock in such a way that the screw lies horizontal to the base with its pointed end directly in a line with the centre line of the shaft in the fixed stock when the tail stock is fitted to the grooved base.

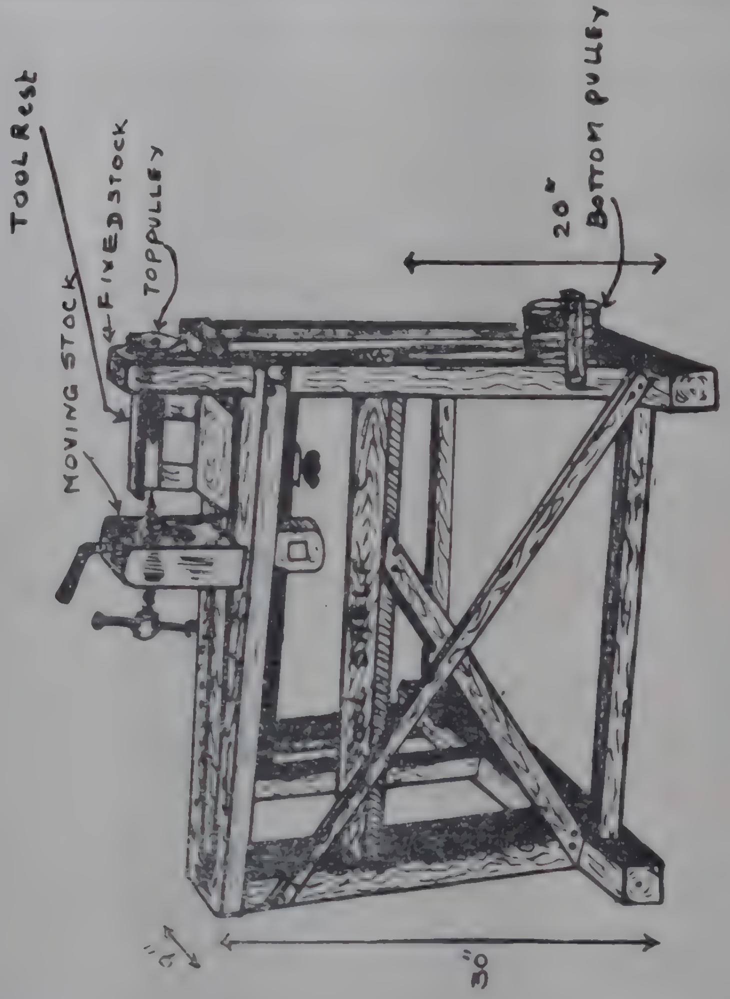
Only the nut portion is embeded into the tail stock allowing the free movement of the screw in the nut. The stock is held tight in position by a wooden wedge. The stock is moved forward or backwards by loosening the wedge and again fixing it after positioning the stock. Finer arrangements are made by the screw. The screw is also kept in position by a vertical screw fixed on the head of the tail stock. After final adjustments to the tail stock screw the top screw tightened and the screw clamped tight. The tip of the tail stock screw serves as a fulcrum to the work piece to rotate freely.

Tool rest.—A tool rest has to be made from M.S. Plate and angles to permit the turner to use his turning chisels. The tool rest is also movable in the base groove of the lathe and can be clamped tight in position by clamping bolt.

All the working parts to be properly greased. A tension cord or leather thong can be used as a belt for the pulleys. The wooden pulleys should be made up of hard wood like Rose wood. It is better to get them turned in a lathe to the required size. The work piece should be free to rotate about its axis and the work piece should be properly dressed and the axis properly centered. One end should be gripped by the fixed stock by its spindle point and the the other end fixed by the tail stock axis by its blunt tip. The work piece should not be clamped too tight. It should be freely movable.

Use always sharp turning chisels for turning. This lathe can be made within a cost of Rs. 50 without the motor. The lathe discribed can take work pieces up to 24 inches in length and 8 inches in diameter. By little practice many useful articles can be turned using this lathe.

(*N.B.*—The measurements given is only a guide; it may be altered to suit the needs of the work and availability of the scrap materials.)


TOOL Rest
FIXED STOCK
TOP PULLEY
MOVING STOCK
20"
BOTTOM PULLEY
30"
6"

WOOD WORKING LATHE

PLATE 1

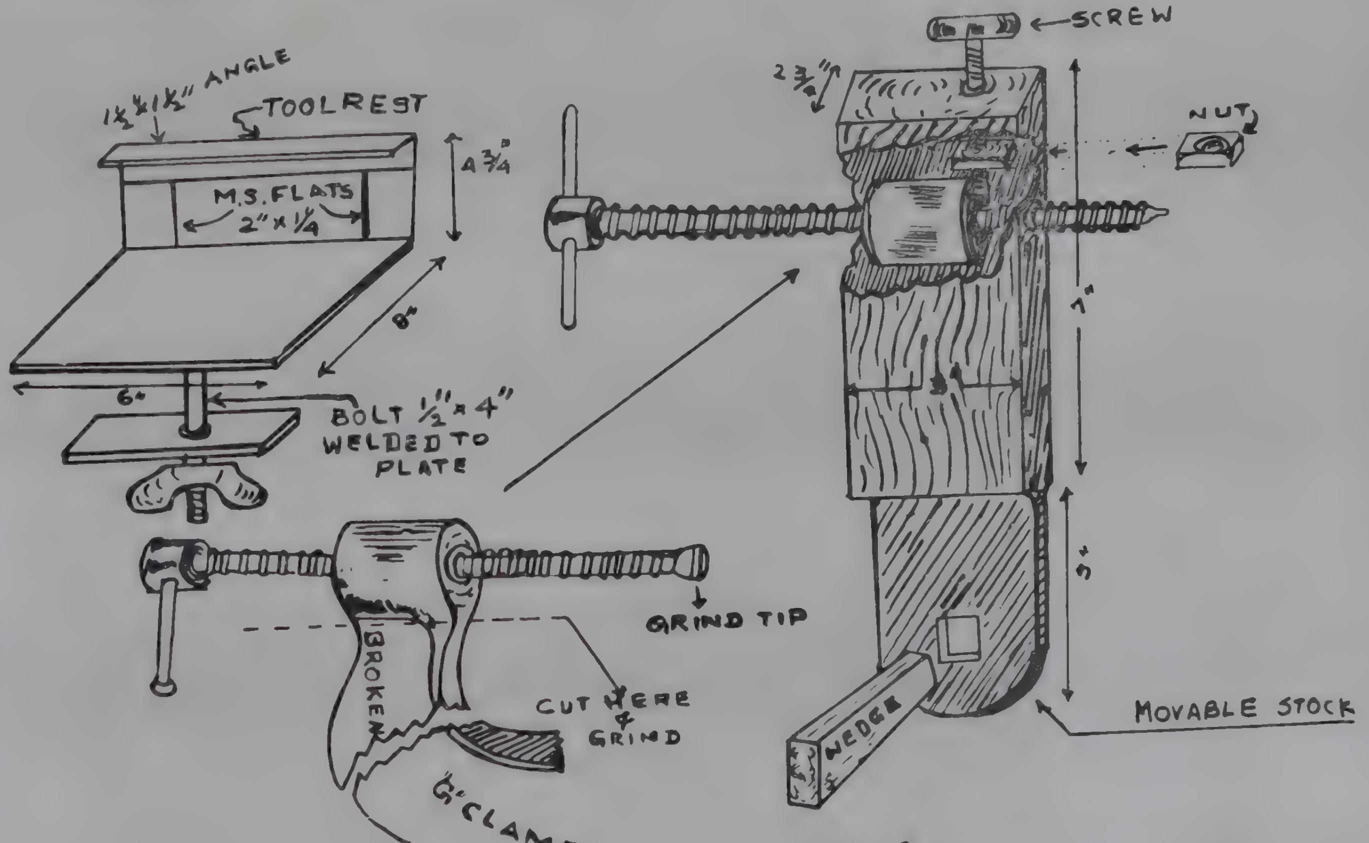

1½"x1½" ANGLE
TOOLREST
M.S. FLATS 2"x1/4
4¾"
8"
6"
BOLT ½"x4" WELDED TO PLATE
SCREW
2⅜"
NUT
7"
3"
MOVABLE STOCK
WEDGE
GRIND TIP
CUT HERE & GRIND
BROKEN
G CLAMP

PLATE 2

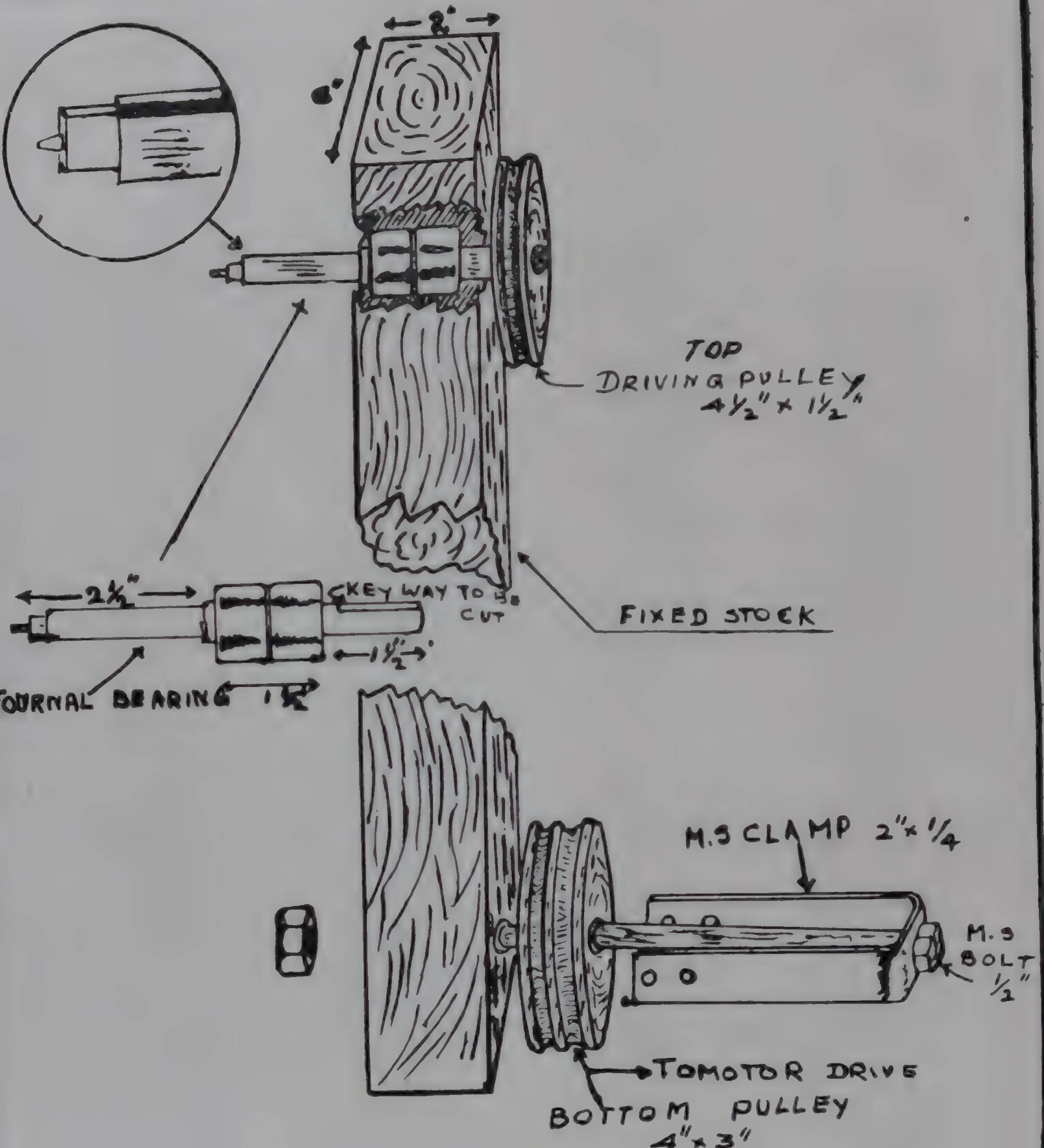

8"
6"
TOP
DRIVING PULLEY
4½" × 1½"
FIXED STOCK
2½"
KEY WAY TO BE CUT
1½"
JOURNAL BEARING
1½
M.S CLAMP 2" × ¼
M.S
BOLT
½"
TOMOTOR DRIVE
BOTTOM PULLEY
4" × 3"

PLATE 3

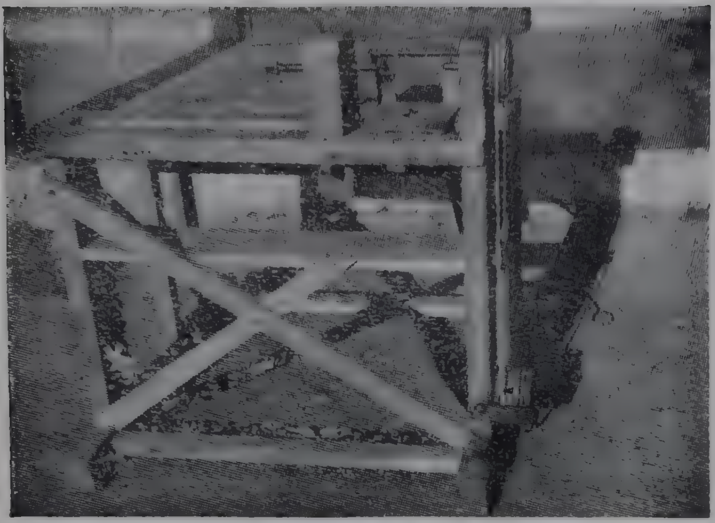


PLATE 4. THE LATHE MADE BY THE AUTHOR.

INSTRUCTIONS TO AUTHORS.

1. Manuscripts of papers offered for publication in the " Madras Journal of Fisheries " should be typed on one side on foolscap paper and double-spaced throughout. Pages should be consecutively numbered. Two copies of the manuscript should be submitted.

2. The title of the paper should be brief and to the point and wholly in capitals. This is followed by the author(s) name(s) with the initials preceding the surname.

3. Tables when given should not contain bulky data and should be given on separate sheets and their position in the text indicated suitably. They should be given brief headings. They should be numbered in Roman numerals and indicated in the text thus : Table I.

4. Both tables and graphs illustrating the same point will not be accepted.

5. Drawings and illustrations should be made in Indian Ink on white Bristol board. Scale of magnification of *camera lucida* drawings should be properly mounted. Every drawing or photograph should be accompanied by the relevant legends. Maps should have the latitude and longitude clearly marked. Figures should be numbered in Arabic numerals and indicated in the text thus : Fig. 1.

6. Names of all simple chemical compounds rather than their formulae should be used in the text.

7. All measurements should be given in the metric system only.

8. Citation of literature should have author, year, title, name of journal, volume number and inclusive pages.

Abbreviations of the names of journals should be according to " *World List of Scientific Publications* " (3rd edition 1952) or to recognised form only.

Examples—Atkins, W.R.G. 1923. The phosphate content of fresh and salt waters in its relationship to algal plankton. J. Mar. Biol. Ass. V 13 ; 119–.50
Harvey, H.W. 1931. *Biological Chemistry and Physics of Sea Water.* Cambridge Univ. Press.

In the text the reference should be cited thus : Ralph and Hurley (1952), with the author's surname followed by the year of publication in parenthesis.

9. All manuscripts should be sent to:

The Director of Fisheries,
Editor, "Madras Journal of Fisheries",
Administrative Office Buildings,
MADRAS-6.

PRINTED BY THE DIRECTOR OF STATIONERY AND PRINTING, MADRAS, ON BEHALF OF THE GOVERNMENT OF MADRAS— 1968

MADRAS JOURNAL OF FISHERIES

Volume V

Edited and Published by
THE DIRECTOR OF FISHERIES, MADRAS

©
GOVERNMENT OF TAMIL NADU
1969

PRINTED BY THE DIRECTOR OF STATIONERY AND
PRINTING, MADRAS, ON BEHALF OF THE
GOVERNMENT OF TAMIL NADU
1969

Price : Rs. 16·05

CONTENTS

PAGE

1 The hydrobiological features, primary production and fisheries of Stanley Reservoir, Mettur Dam by A. Sreenivasan. 1

2 Prawn culture at the Brackishwater Fish Farm, Adyar, Madras by Thmt. Gemma Evangeline 18

3 On the lobster fishery trend and conservancy measures in Kanyakumari district, Madras State by P. I. Chacko, R. Srinivasan and R. Anantanarayanan 72

4 Effect of organic and inorganic manures on plankton production and dissolved oxygen content of fish nurseries by A. Sreenivasan, R. Soundararaj and T. Franklin 82

5 Conditions of existence in twenty pearl banks in the Gulf of Mannar off Tuticorin during 1962–63 by P. I. Chacko and P. S. Sambandamurthy 94

6 Report on the survey of pearl banks off Ramanathapuram Coast during 1965 by A. D. Isaac Rajendran and Freda Chandrasekaran 100

7 Preliminary observations on chank marking experiments conducted at Tuticorin, Gulf of Mannar, during 1962–63 by P. S. Sambandamurthy and P. I. Chacko 105

8 Statistical studies on the commercial catches of Chanks fished off Tuticorin, Gulf of Mannar in 1962–63 by P. S. Sambandamurthy and P. I. Chacko 110

9 Phytoplankton of Bhavanisagar reservoir by T. Franklin 112

10 Survey of fishing grounds in the inshore-waters of Bay of Bengal near Madras in 1966–67 by P. I. Chacko, Mohamed Sultan and Kanakaraj David. 119

11 Survey of inshore waters of South Arcot District Coast in 1966–67 by P. I. Chacko, M. V. Natarajan and E. Edwin Joseph 123

12 A preliminary hydrobiological survey of certain estuaries in the Chingleput district by Thirumathi Gemma Evangeline, P. Mohanakrishnan and Selvi K. R. Seethalakshmi 123

13 Hydrobiology and fishery of the Ennore Estuary from June 1965 to May 1967 by Thirumathi Gemma Evangeline and K. Subbiah 139

14 Prawn grounds off Madras by P. I. Chacko and A. Daniel 152

15 A note on copepod parasites in fish of the Vellar Estuary at Porto Novo by Thirumathi Gemma Evangeline and V. Venkatesan 154

16 An instance of large scale parasitism of Sacculina on the edible crab Neptunus pelagicus by P. S. Sambandamurthy and P. I. Chacko 156

17 A study of the structural components of the adhesive disc of Echeneis (Artedi) and their functions, Part II-skull and first five vertebrae by B. Bonnell and Mrs. Jeyachandran 158

18 The oral breathing valves of Echeneid fishes and their probable influence on the movements of the components of the adhesive disc by B. Bonnell and Mrs. K. Jeyachandran 163

19 Observations made on a living sucker fish Echeneis (S.P.) by B. Bonnell .. .. – 165

THE HYDROBIOLOGICAL FEATURES, PRIMARY PRODUCTION AND FISHERIES OF STANLEY RESERVOIR, METTUR-DAM FOR THE YEARS 1958 TO 1965

By

A. SREENIVASAN, *Hydrobiological Research Station, Madras-10, South India.*

Introduction.

The importance of fish protein to feed the growing population has turned our attention to man-made reservoirs for increased production of this important protective food. Basic knowledge on the hydrobiological conditions of tropical impoundments is becoming available recently (Sreenivasan 1964, 1965 a, b). One such reservoir, Bhavanisagar, was dealt with in detail in one of the publications cited above. Stanley Reservoir, Mettur Dam, has about twice the area and three times the volume of Bhavanisagar reservoir. Further, complete commercial fishing data for Stanley Reservoir is available for over a decade. Hence it was felt that a compilation of this data would be of immense use.

Raj (1942) believed that impoundments on river systems greatly affect the fish and fisheries but the conjecture was based perhaps on temperate water migratory fishes like salmon, trout and the Indian Hilsa. Bhimachar (1959) viewed it in more correct perspective when he stated that " most of the high dams of India are created in the middle and upper reaches of rivers and the adverse effects of such obstructions on the fish population of the area are not likely to be appreciable ". This, very nearly corresponds to the situation in our artificial reservoirs. Schuster *et al* (1954) pinpointed the effect of impoundments on fish with a poser . . . " the question whether indigenous species can populate effectively and usefully the new body of water and whether new species must be introduced ". The impact of reservoirs on water quality has been very lucidly discussed by Neel (1963). When the flowing water of rivers are obstructed and reservoirs formed, the ecological conditions are bound to alter. The greatest change is in the physical environment, viz., the flow of water, the thermal structure, etc. Chemical conditions of the water and plankton also vary.

Material and Methods.

The reservoir water was sampled with a Friedinger deepwater sampler and the analysis for dissolved gases and dissolved ions determined by standard methods, soon after collection. Plankton was collected by passing 10·0 L of water through nylon fabric having 50 meshes per cm. (Net plankton). Primary production was determined by the 'Light and dark bottle' method.

Results.

Data on the volume, area, depth, position of outlets, etc., are furnished in great detail in an earlier publication (Sreenivasan 1966). The hydrological conditions are shown in graphs in fig. 1. Tables I, II and III contain data on productivity, plankton and fish landings. A short account of some of the parameters will be given here. The highest surface temperature was 32·0 ° C in May 1962 whereas the lowest was 24·2 ° C in January 1963. The highest temperature of the bottom water was 32·0 ° C, noted in May 1962. The dissolved oxygen content of the surface water ranged from 2·3 mg./1 (during low water conditions in April 1963) to 10·1 mg./1 in May 1962, and 12·9 mg./1 during October 1962. The dissolved oxygen in the bottom varied from nil in April 1965 to 6·8 mg./1 in October 1962 and December 1963. Supersaturation levels are never high-the maximum reached being 130 per cent only. The pH value of the surface water is never lower than 7·5 and the highest value recorded was 8·8. Even the bottom water always had a pH of over 7·2. Variations in methyl orange alkalinity were noted over seasons but vertical variations were not great. In July of 1963 and 1964, the methyl orange alkalinity was low 62-63 PPM. and at other periods it was over 140 PPM. maximum being 278 PPM. The electrical conductivity was 170 umho at the lowest and 350 units at the highest. The contiously low level of the reservoir during March to June 1963 and 1964 needs special mention. Fishing was almost stopped during this period to conserve breeders and stock.

Discussion—Thermal condition.

During the entire period of study, there was no instance of stable thermal statification in this deep reservoir. The nearest to a true stratification was noted on March 1964 an ephemeral 'epilimnial' thermocline occurred. The greatest difference between the surface temperature and that of the bottom noted was only 3·7° C on 14th October 1962 (depth 25 m.). Near homothermal conditions prevailed during January. This is due, not to any mixing up or influx of cooler water as in Bhavanisagar Reservoir (Sreenivasan 1965 a) but due to heavy outflow from lower levels removing the comparatively cooler waters. This confirms to the findings of Vivier (1960). Ruttner's statement that tropical waters are characterized not so much by the thermal gradient but by the very warm bottom temperature, is proved by our data for this reservoir. The water temperature is influenced by the inflow and outflow of water. High summer temperature in May 1962 was gradually reduced by the voluminous outflow and inflow, mixing up the water causing poor thermal gradient between the surface and bottom. During January 1963, though the inflow was low, outflow was greater and this could have prevented stratification. Though the temperature of water was high in March 1965, it was suddenly lowered in April. In May 1963, the temperature again reached a peak. The 'relative thermal resistance' was low despite great depth-it was 135 units in October 1962 and 73 units in March 1963 and less than 50 units at other periods.

Oxygen regime.

This has a bearing on the distribution of fishes in the reservoir and of other organisms and on selfpurification in the river below the reservoir. The surface water of the reservoir invariably had an oxygen content over 5·0 mg/1. In summer months oxygen deficit was severe in the bottom layers (May 1962, March 1963 April 1965) and oxygen gradient was established between the surface and bottom. Harding (1961) noted oxygen depletion below thermocline in Lake Kariba in Africa. The very low oxygen content in the surface water in May 1963 was due to the very low water level which, bringing up suspended silt prevented photosynthesis and also removed oxygen. The oxygen and temperature curves in fig. 1 shows the inverse relationship between the water temperature and oxygen content. Mild oxygen supersaturation was noted in the surface waters on many occasions. 'Oxygen deficit' for this reservoir has been worked out according to Theinemann (1928). The entire reservoir was taken as a unit instead of the 'hypolimnion' since there is no well marked hypolimnion. The deficit has ranged from 0·64 mg./1 to 5·84 mg./1. If this is calculated for a 'hypolimnion' it would be higher. Hypolimnion oxygen deficit is an indication of eutrophication (Thienemann 1926). The total oxygen content of the reservoir for some days was worked out from the dissolved oxygen profile and the volume of water under each profile. It ranged from 3,060,400 Kg. oxygen in May 1962 to 20,715,000 Kg. in October 1962. This is a tremendous quantity and would be of immense use downstream. An interesting feature worth recording is that when the oxygen content of the lower layers of the reservoir water was very low or nil, the same water issuing out through the power house turbine or low level sluices was very well oxygenated within a distance of 180 meters. On 29th April 1965, the reservoir water at 19·0 m. depth was devoid of oxygen, but the same water after discharge through the power house had gained 6·4 mg./1, within a distance of 100 m. downstream. Likewise on 21st January 1963, the water at 30 m. depth had only 3·4 mg./1 dissolved oxygen but the discharge water contained 6·0 mg./1. Thus, with our reservoirs, the discharge of bottom waters with oxygen deficits through sluices or turbines does not affect the quality of river water. Actually better oxygenated water issues forth, in contrast to American experience (Churchill 1958). Reid (1961) also remarked that "the release of water from a reservoir through deep level intakes . . . introduce poorly oxygenated water from the hypolimnion into the stream below". But Neel (1963) agrees that "Reservoirs often increase a stream's Oxygen resources". The high oxygen suspersaturation as in Bhavanisagar (Sreenivasan 1965 a) however, were not noted in Stanley Reservoir.

pH value and alkalinity.

The pH value of the surface water was always over 7·5 the maximum reached beeing 8·8. Even the pH value of bottom water was invariably over 7·2, the highest reached being 8·5. Stratification of pH was noted frequently, the maximum difference being 1·5 units. Allanson and Giesskes (1961) also noted that in Hartheespoort Dam, the pH never dropped below 7·0, being well buffered, but reached a value of 9·0 in summer. In Stanley Reservoir also, a pH of 9·1 and oxygen supersaturation were recorded during October 1962 in the afternoon hours. The close relationship between free CO_2 phenolphthalein alkalinity and methyl orange alkalinity is strikingly noted in the graphs in Fig. 1. The curves of pH and phenolphthalein alkalinity are almost parallel. The methyl orange alkalinity is fairly high and the surface water had lower bicarbonate than the bottom water because of its being utilised by photosynthetic phytoplankton in the euphotic zone. But there was no significant stratification.

Chlorides.—Did not vary much, the range being 19·0-37·0 mg./1. Low chloride indicates relative absence of pollution.

Hardness.—Varied within narrow limits, 86-128 P.P.M. as $CaCO_3$. This may be classified as a 'hard' water.

Electrical Conductivity.—Parallelled the methyl orange alkalinity and ranged from 170 to 359 umhos. Seasonal variations noted here resembled those for a Swedish Reservoir described by Rodhe (1964). The high conductivity indicates the high dissolved solids content and hence high productivity (Rawson 1958).

"*Oxygen Absorbed*".—Tidy's figures varied from 0·5-4·75 P.P.M.

Calcium.—Varied from 11·0 to 20·3 P.P.M (as Ca). Despite the high hardness the low calcium indicates its negligible contribution to hardness.

Phosphate.—Soluble inorganic phosphate was rarely present. In January 1963 the total phosphorus was 3·2 P.P.M.

Silicate.—Ranged from Nil to 19·9 P.P.M. but this could not be correlated with any other factors.

Nitrate was not present at any time.

Plankton.

The diatoms, *Nitzschia* and *Navicula* were ubiquitous and were noted throughout the period of study. *Merismopedia* and *Oscillatoria*, the blue green algae occurred less frequently. *Microcystis* was noted only from late 1964. Other genera of algae noticed on different occasions are, *Euglena, Peridinium Desmidium, Cylindrospermum, Synedra, Cyclotella, Nostoc, Spirulina, Tetrapedia, Chlorella, Microcoleus* and *Tetrastrum.* 'Net plankton' was generally very poor but nannoplanktonic organisms were present in considerable numbers (*See* also Rodhe 1964). January to April appeared to be the period when plankton was abundant. This is correlated with lesser inflow, increasing temperautre and increasing solutes. Nannoplankton were twelve times the volume of 'net' plankton. We have noted in the soft water Amaravathy reservoir (Sreenivasan 1965 b) blooms of *microcystis,* and Allanson and Giesskes (1961) found blooms of *Oscillatoria* and *microcystis* in a South African reservoir but in Stanley reservoir such blooms were not noticed. In this reservoir, no seasonal pattern in distribution could be discerned. Brook (1963) found that many planktonic desmids occurred in alkalinity ranges below 100 PPM. It is therefore interesting to record here that desmids occurred only once during the present study.

Zooplankton Organisms comprised *Brachionus, Cyclops, Eubranchipus, Daphnia, Anurea, Anapus, Polyarthra, Monostyla* and *Nauplii* larvae. Larves of culicids were also noted. On some occasions Zooplankters were not found in the net plankton collections. During very low water levels in March-April of 1963 and 1964 Zooplankters were either absent or scanty. Possibly they must have been flushed out by the outflow (Axelson 1961).

Primary production.

The gross primary production in this reservoir ranged from 1.05 g. O^2/m2/day to 10.97 g. O_2 m^2/day. The lower yield was due to high silt turbidity during the very low water level in April1964 . The primary production is generally high. Secchi disc visibility is about 1·0 m and the photosynthetic zone extends to a little below 5·0 m. The silt turbidity following the floods, settles down soon and the water is clear giving scope for the phytoplankton to carry on photosynthesis. Lower primary production in July is correlated with high water levels-floods, dilution and turbidity being the causes. Higher primary production in January follows fairly stable water levels and higher phytoplankton content. The maximum rate of photosynthesis was higher in Amaravathy Reservoir (Sreenivasan 1965 b) because of surface bloom of blue greens in this water, than in Stanley Reservoir with better chemical paramenters. The older Stanley Reservoir, with higher alkalinity, hardness, dissolved salts, pH, Calcium, etc., is not more productive than the newer Amaravathy Dam. But the primary production is greater than in some of the Russian impoundments, for which data are available (Sorokin 1958, 1959). A "River lake" on White Nile showed a primary production of 2.2 g. C/m2/day (Prowse and Talling 1958). Comparative productivity rates can also be gleaned from Table I. Productivity, as measured by diurnal changes in Oxygen was moderate. Maximum rate of photosynthesis in euphotic zone was a little lower than in Amaravathy Reservoir.

Fish yield in the Reservoir.

Commercial fish catches for the reservoir for five years is recorded in Table II. The catches of 1962-1963 and 1963-1964 are of the same magnitude as during the previous four years. The catches during 1964-65 were only nearly half of the previous years catches. This reduction was due to the restricted fishing during summer months of 1964-65, because of very low water levels. The extremely low water levels of March-April-May of 1963 and 1964, have in fact brought about a change in the composition of the fish catches. In a previous publication (Sreenivasan 1966) the catch composition for five years was furnished. in which the share of *Catla* in total catches increased year by year to a peak of 39·6 per cent in 1961-62. But in 1963-64, it fell to 30·8 per cent and in 1964-65 to 17·5 per cent. *Cirrhina* cirrhosa decreased from 36·2 per cent in 1961-62 to 20·8 per cent in 1962-63 and did not decrease further. *Cirrhina mrigala* showed an increase but the most spectacular change was in catfishes which rose gradually from 17·3 per cent in 1961-62 to 50·1 per cent in 1964-65. An increased yield of eels was noted in 1962-63 and in 1963-64. The changes may be due to the poor oxygenation of waters and turbid conditions during the very low water levels which would have caused a downstream migration of *Catla* and *C.cirrhosa*. Similar escape of fishes through sluices, downstream in DVC reservoirs has been observed (Anon). The catfishes, more resistant to these adverse environment survivied and continued to increase. Swingle (1953) noted certain changes in fish populations following impounding-decrease in catfishes and increase of gizzard shad.

The average effective waterspread of the reservoir may be considered to be 7,500 ha (half the area of full reservoir level). On this basis the yield worksout to 55-60 Kg./ha. Over a period of many years, the fish yield in Stanley Reservoir is steady. Tarzwell (1943) has stated that " . . . . . it is clear that some impoundments are capable of maintaining . . a high level of productivity over considerable periods . . . . tends to refute the idea that productivity of all impoundments declines as they become older ". Our data support this statement. This high fish yield is comparable to those in the Reservoir of U.S.S.R. and better than those of the reservoirs in U.S.A. and China (Borgstrom 1964, Lipitzsky 1965).

Fish yield and Primary Production.

The average primary production for the period under discussion is 6·2 gO_2/m^2/day. Calculated on an annual basis, it is 22,630 Kg. O^2/ha/annum. The present fish offtake has amounted to 55-60 Kg./ha/A, which is 0·25 per cent of the primary production. In smaller pieces of waters-ponds and tanks-higher conversions have been obtained. For want of comparable data it is not possible to affirm if this is the optimum but we feel that at least 1 per cent of primary production could be converted to fish, yielding about 225 Kg./ha/A through plankton feeding major carp species.

Summary.

The limnological features of Stanley Reservoir, a 60 square mile impoundment on Cauvery river at Mettur Dam, are described. Thermal stratification was uncommon but stratification of dissolved oxygen was common. The alkalinity, pH, hardness, elecrtical conductivity, etc., were fairly high but phosphate was rarely found. Reaeration of bottom waters of low oxygen content was quick. A large amount of dissolved oxygen was present in the reservoir, which will be useful in receiving wastes downstream. Primary production was high but net plankton appeared to be poor. Nannoplankton were more abundant. Only a few species of zoo plankters were noted. Some diatom species like *Nitzschia* and *Navicula* were ubiquitous. Bloom algae were not noted. The fish yield amounted to 55-60 Kg./ha which was 0·25 per cent of the primary production. The changes in species composition of fishes during 1964-65 are explained.

Acknowledgement.

Author's thanks are due to Ms. N. V. Choodamani and V. Renganathan, Deputy Directors of Fisheries for their keen interest and encouragement.

References.

Anon: (Undated)—Project Report on the Fisheries Development of the DVC Reservoirs, Central Fisheries Corporation (Mimeo).

Allanson. B. R. and Giesskes. J.M.T.M.—" An introduction to the limnology of Hartbeespoort Dam with special reference to the effect of Industrial and domestic pollution ", Hydrobiologia 1961, 18 ; 77-94.

Axelson, J.—" Zooplankton and impoundment of two lakes in Northern Sweden (Ranaren and Kultsjon ", Rept. Inst. Freshw. Res. Drottingholm 1961, 41 : 84-168.

Bhimachar, B. S.—" Inland Fisheries of India and their problems ". Presidential address, Zool. Sect. 46th Indian Sci. Congr., New Delhi, 1959.

Borgstrom, G. 1964—" Fish as Food" Vol. 2 Ch. 7. 267-360.

Brook. A. J.—" Planktonic algae as indicators of Lake types with special reference to the desmidiaceae. Limnol and Oceanogr. (1965) *10*(3): 403-411.

Churchill, M. A.—" Effects of impoundments on oxygen resources' in " Oxygen relationships in streems ". 1958-T.R. No. W. 58-2. R.A. Taft. Eng. Centre US PHS 107-130.

Harding D.—" Limnological trends in Lake Kariba. Nature (London) 1961, 191: 119-121.

Hutchinson, G. E.—" A Treatise on Limnology " Vol. I 1957 John Wiley & Sons, 1-1105.

Lapitzsky, I. I., 1965—" Development of Fishery and the Ways of raising fish productivity of big reservoirs ". " Seminar on fish culture in Inland Waters of the USSR ". July-August 1965: 1-24 (Mimes).

Neel, J. K.—" Impact on Reservoirs " in limnology in North America. Ed. D. G. Frey. Univ. Wisconsin Press, 1963, 575-594.

Prowse, G. A. and Talling, T. F.—" The seasonal growth and succession of plankton algae in the white Nile " Limnol and Oceanography 1958, 3(2): 222-238.

Raj, B. Sundara " Dams and Fisheries ".—Mettur and its lessons to India. Proc. Ind. Acad. Sci. 1942, 14B: 341-358.

Reid, G. K.—" Ecology of Inland Waters and Estuaries ". Reinhold N.Y. 1961, 374 p.

Rodhe. W.—" Effects of impoundments on water Chemistry and plankton in Lake Ransaren (Swedish Lappland). Verh. Internat. Verein. Limnol. 1964, XV. 437-443.

Ruttner. F.—" Fundamentals of Limnology " (Transl.) Univ. Toronto Press, 1953. 1-242.

Sorokin, K. Cited by Pirezhikov. P.L. and Mirochinchenko M.P. in " Seminar on Fish culture in Inland Waters of the USSR ". Leningrad-Moscow. July-August 1965. Lecture No. 4 Mimeo 1-25.

Schuster, W. H. Kesteven, G. L. and Collins G.E.P.—" Fish forming and inland Fisheries management in Rural Economy " FAO. Fisheries Study No. 3, 1-64.

Sreenivasan, A.—" Limnological studies of Tropical impoundments II. Hydrological features and plankton of Bhavanisagar Reservoir for 1961-62 ". Proc. Ind. Acad. Sci. 1964, 59B: 53-71.

Sreenivasan, A.—" Hydrobiological study of tropical impoundment Bhavanisagar Reservoir, Madras State, India for the Years 1956-1961 " Hydrobiologia 1965 a 24(4): 514-535.

Sreenivasan, A.—" Limnological studies of Tropical impoundments III. Limnology and productivity of Amaravathy Reservoir (Madras State). India Hydrobiologia. 1965. Vol. XXVI 501-516.

Sreenivasan, A.—" Limnology of Tropical Inpoundments I. Hydrological features and fish production in Staney Reservoir Mettur Dam. International. Rev. Ges. Hydroliol. 1966, 51 (1): 295-306.

Swingle, H. A.—" Fish populations in Alabama rivers and impoundments " Trans. Amar. Fish. Soc., 1953. 83: 47-57.

Tarzwell, C. M.—" The possibility of a commercial fishery in the TVA impoundments and its value in solving the sport and rough fish problems ". Trans. Amar. Fish. Sec. 1943. 73: 137-157.

Thienemann, A.—" Dem Sauerstof in Eutrophen and Oligotrophen See. " Die Binnen Gewasser 1928 BD. IV., 1-175.

Viver, P.—" Temperature et oxygen dissous on profondent dans les lacs barage artificiales francias ", Schweiz, Z. Hydrol. 1960, 22; 350-369.

TABLE I—*Showing primary production and related data of Stanley Reservoir.*

Date.	Primary production G.02/day..		Community respiratcon mg. 02/1/hr.	Secchi disc. visibility m.	Productivity measurements.		
	Maximum rate per m3 in euphotic zone.	Gross primary production per m2.			By natural changes in 02 U mol/1/hr.	By changes in co2 and alkalinty U mol co2/1/hr.	By max. rate of photosynthesis in euphotic zone umol/02/1hr.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
14th May 1962	4·20	8·46	0·10	1·04	..	..	..
14th October 1962	4·80	8·82	0·07	1·12	1·57	50	11
21st January 1963	2·10	7·35	0·05	0·72	4	34	5·6
7th March 1963	2·40	4·80	0·30	0·64	..	..	..
29th April 1963	2·10	1·05	0·13	0·50	..	..	..
31st July 1963	1·80	3·60	0·00	0·85	4	17·5	4·8
4th December 1963	1·50	6·00	0·00	1·05	0	5·0	4·0
31st January 1964	6·17	10·97	0·30	0·67	2	..	16·0
23rd March 1964	3·00	4·35	0·05	..	14	..	9
30th December 1964	3·60	2·10	0·05	..	3	..	6
23rd January 1965	3·4	7·5	0·07	0·80	7·7	32	9
29th April 1965	4·5	6·15	0·03	1·25	7·3	28·0	11·7
10th July 1965	5·7	9·53	0·01	0·78	8	2·5	14·8

TABLE II—*Fish catches and species composition of fishes from Stanley Reservoir.**

Species.	1960–61		1961–62		1962–63		1963–64		1964–65	
	Weight in kg.	Percentage of total.	Weight in kg.	Percentage of total.	Weight in kg.	Percentage of total.	Weight in kg.	Percentage of total.	Weight in kg.	Percentage of total.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Catla catla	150,732·2	37·2	137,734·5	39·6	168,906·5	38·1	125,745·1	30·8	38,991·8	17 5
Cirrhina Cirrhosa	156,130·8	38·7	123,513·2	36·2	92,184·0	20·8	82,402·4	20·2	54,663·8	24·5
C, mrigala	20,890·4	5·2	21,239·9	6·1	34,853·0	7·9	42,469·1	10·4	16,891·8	7·6
Catfishes	72,979·5	18·0	60,308·1	17·3	131,407·7	30·0	140,963·4	34·6	111,689.3	50·1
Other species	3,544·4	0·9	2,569·9	0·7	7,104·8	1·6	16,401·4	4·2	411·0	0·2
Total	403,739·0	..	347,645·0	..	443,450·0	..	407,981·4	..	222,646·6	..

* From the Registers of Mettur Dam Fishermen Co-opertive Marketing Society.

TABLE III.

Plankton of Stanley Reservoir.

Date. (1)	*Phytoplankton.* (2)	*Nos.* × 1000/l (3)	*Zooplankton.* (4)	*Per L* (5)
11th May 1962	*Peridinium*	400	Nil.	
	Navicula	120		
13th October 1962	*Peridinium*	220	*Polyarthra*	20
	Nitzschia	840	*Nauplii*	20
	Oscillatoria	5,000		
	Nitzschia	70	Nil.	
	Oscillatoria	3,500		
	Merismopedia	Nil.		
7th March 1963	*Cylindrospermum*	3,000	*Monostyla*	20
	Peridinium	150		
	Nitzschia	300		
	Navicula	120		
	Microcystis	60		
	Merismopedia	180		
	Oscillatoria	2,500		
28th March 1963	*Nitzschia*	3,200		
	Navicula	6,500		
	Merismopedia	500		
	Oscillatoria	5,000		
29th April 1963	*Nitzschia*	160		
	Oscillatoria	1,500		
14th March 1963	*Euglena*	200	*Daphnia*	100
	Desmidium	500	*Nauplii*	200
	Synedra	300		
	Nitzschia	100		
	Cyclotella	200		
	Navicula	200		
	Spirulina	200		
31st January 1964	*Euglena*	300	*Cyclops*	300
	Desmidium	100	*Nauplii*	
	Synedra	100		
	Nitzschia	200		
	Cyclotella	200		
	Navicula	300		
	Merismopedia	200		
	Oscillatoria	200		
	Spirulina	200		
23rd March 1964	*Euglena*	300	*Nauplii*	200
	Synedra	100		
	Nitzschia	200		
	Navicula	200		
	Microcystis	200		
	Merismopedia	200		
30th December 1964	*Navicula*	200	*Cyclops*	100
	Microcystis	400		
	Spirulina	500	*Brachionus*	200

TABLE III—*cont.*

Plankton of Stanley Reservior—cont.

Date. (1)	*Phytoplankton.* (2)	*Noz* × 10t0/1 (3)	*Zooplankton,* (4)	*For L* (5)
25th January 1965	*Navicula*	3,000	*Brachionus*	2000
	Microcystis	3,000	*Cyclops*	1,000
	Merismopedia	2,500	*Eubranchipus*	750
	Nostoc	4,000	*Anurae*	500
	Tetrapedia	1,000	*Nauplii*	2,000
	Chlorella	5,000	*Culicid larva*	1,000
29th April 1965	*Peridinium*	5,000	*Anapus*	2,000
	Synedra	4,000		
	Nitzschia	3.000		
	Cyclotella	4,000		
	Microcystis	2000		
10th April 1965	*Euglena*	200	*Eubranchipus*	2,000
	Peridinium	300		
	Nitzschia	3.000		
	Navicula	200		
	Microcystis	2.000		
	Merismopedia	300		
	Tetrastrum	100		
	Microcoleus	600		

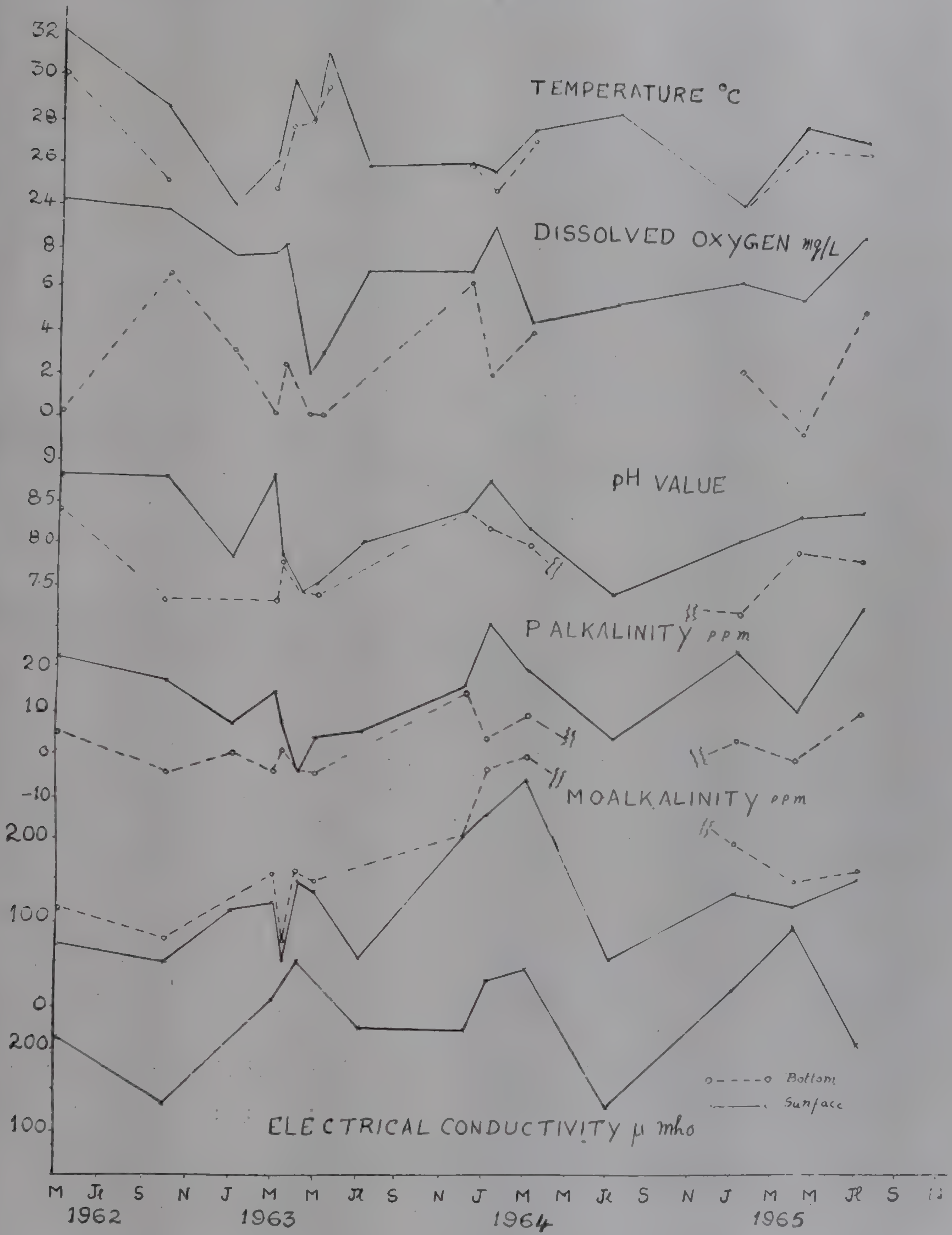

TEMPERATURE °C
32
30
28
26
24
DISSOLVED OXYGEN mg/L
8
6
4
2
0
9
pH VALUE
8.5
8.0
7.5
P ALKALINITY ppm
20
10
0
-10
MO ALKALINITY ppm
200
100
0
200
100
ELECTRICAL CONDUCTIVITY μ mho
o----o Bottom
—— Surface
M
Jl
S
N
J
M
M
Jl
S
N
J
M
M
Jl
S
N
J
M
M
Jl
S
1962
1963
1964
1965

TABLE IV.

(1)	10, *February* 1958. 16·00 hours. (2)	(3)	(4)	(5)	(6)	(7)	10, *February* 1958. 22·00 hours. (8)	(9)	(10)
1 Temperature °C	28·8	28·82	27·6	27·5	27·7	27·6	26·8	26·8	26·8
2 Depth m.	0·0	5·0	10·0	15·0	20·0	25·3	0·0	5·0	10·0
3 Free CO2: mg/L ..	0·0	0·0	0·0	0·0	0·0	1·76	0·0	0·0	0·0
4 CO_3 mg/L	30·0	15·0	6·0	3·0	3·0	0·00	24·0	24·0	9·0
5 HCO_3 mg/L	109·8	140·3	143·4	158·6	158·6	176·9	112·9	109·8	140·3
6 pH	8·3	8·3	7·8	7·7	7·7	7·7	8·3	8·2	8·2
7 Dissolved Oxygen mg/L ..	4·2	5·7	2·4	2·4	2·4	2·0	2·9	3·2	2·3
,, per cent saturation.	55	74	34	31	31	26	37	41	29
8 Chlorides mg/L	15·0	15·0	16·0	15·0	15·0	15·0	18·0	16·0	16·0
9 Silicate mg/L	10·0	10·0	10·0	10·0	..	..	18·0	14·0	12·0
10 Phosphate P mg/L ..	Nil	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0
11 Hardness ($CaCO_3$) PPM ..	..	..	..	..	..	..	58·0	60·0	..

11th *February* 1958.

5·00 hours.

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1 Temperature °C ..	26·6	26·4	26·2	26·2	25·6	25·4	25·3	25·0	28·6
2 Depth m	15·0	20·0	0·0	5·0	10·0	15·0	20·0	25·0	0·0
3 Free CO_2: mg/l ..	0·0	1·76	0·0	0·0	0·0	0·99	1·1	2·2	0·0
4 CO3 mg/L	6·0	0·0	15·0	12·0	3·0	0·0	0·0	0·0	18·0
5 HCO_3 mg/L	143·4	109·8	131·2	134·2	152·5	158·6	161·7	170·8	134·2
6 pH	8·1	7·6	8·2	8·2	7·9	7·6	7·7	7·4	8·3
7 Dissolved Oxygen mg/L ..	2·1	2·0	4·2	4·5	4·0	2·5	1·2	0·3	7·2
,, per cent saturation	27	25	53	56	50	31	15	3·7	94
8 Chlorides mg/L	16·0	16·0	15·0	15·0	16·0	16·0	15·0	15·0	..
9 Silicate mg/L	12·0	12·0	12·0	12·0	10·0	10·0	10·0	..	..
10 Phosphate P mg/L ..	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	..
11 Hardness ($CaCO_3$) PPM ..	..	..	..	..	..	..	..	..	..

	11th February 1958. 14·30 *hours.*				*Tiruvani.* 12*th February* 1958. 10·30 *hours.*		*Pannavadi area* 12*th February* 1958. 11·0 *a.m.*		
	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
1 Temperature °C ..	27·8	27·4	27·2	27·0	26·6	28·4	27·8	27·8	27·8
2 Depth m.	5·0	10·0	15·0	20·0	25·0	0·0 (surface)	5·0	10·0	15·0
3 Free CO_2: mg/L ..	0·0	0·0	0·0	0·0	1·76	0·0	0·0	0·0	0·0
4 CO_3 mg/L	18·0	15·0	3·0	1·5	0·0	21·0	21·0	18·0	6·0
5 HCO_3 mg/l	128·1	137·3	161·7	155·6	167·8	192·2	ND	ND	201·3
6 pH	8·3	8·2	7·7	7·9	7·5	8·3	8·3	8·2	8·0
7 Dissolved Oxygen mg/L	6·6	5·1	4·4	4·2	1·1	4·8	3·9	3·1	2·9
,, per cent saturation ..	85	65	56	53	14	62	50	40	37
8 Chlorides mg/L	..	..	..	..	..	19·0	19·0	18·0	18·0
9 Silicate mg/L	..	..	..	..	..	14·0	14·0	14·0	14·0
10 Phosphate mg/L ..	..	..	..	..	..	0·0	..	..	..
11 Hardness (CaCO3) PPM ..	..	..	..	..	..	..	..	..	..

TABLE V.

	10th July 1958.					11th July 1958.				
	16·00 hours.					6·00 hours.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1 Temperature °C	27·8	27·2	27·0	27·0	27·0	27·4	26·8	26·2	25·6	25·4
2 Depth m.	0·0	5·0	10·0	15·0	23·0	0	5·0	10·0	15·0	23·0
3 Free CO_2: mg/L	0·0	0·0	0·0	0·0	1·1	0·0	0·0	0·0	1·21	1·32
4 CO_2 mg/L	27·0	15·0	9·0	6·0	0·0	18·0	9·0	3·0	0·0	0·0
5 HCO_3	94·55	103·7	94·55	100·65	98·6	118·9	106·8	128·1	98·6	91·5
6 pH	8·7	8·7	8·0	7·8	7·5	8·7	8·1	7·6	7·4	7.4
7 Dissolved Oxygen mg/L	9·1	7·1	6·9	6·9	5·2	6·2	7·6	7·1	7·7	4·8
,, per cent saturation	117·0	91	88	88	66	72	96	89	96	60
8 Chlorides mg/L	20·0	20·0	20·0	16·0	14·0	..	..	..	..	..
9 Silicates mg/L	13·0	13·0	13·0	11·2	Tr.	..	..	..	..	..
10 Phosphate P mg/L	Nil	Nil	0·004	Nil	Nil	..	..	..	..	..
11 Hardness (CaCO3) P.P.M.	..	..	..	..	..	..	..	..	..	..

	11th July 1958.					11th July 1958.				
	12·00 hours.					18·00 hours.				
	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
1 Temperature °C	29·0	27·8	27·2	26·8	26·6	27·2	26·8	26·6	26·2	26·0
2 Depth m.	0·0	5.0	10·0	15·0	27·0	0·0	5·0	10·0	15·0	20·5
3 Free CO_2: mg/L	0·0	0·0	0·154	0·638	0·638	0·0	0·0	0·0	1·32	1·43
4 CO_2 mg/L	24·0	15·0	3·0	0·0	0·0	12·0	9·0	3·0	0·0	0·0
5 HCO_3	103·7	92·35	98·6	109.8	..	118·95	103·7	125·1	94·55	118·9
6 pH	8·7	8·4	7·8	7·5	7·3	8·8	8·7	8·3	7·8	7·8
7 Dissolved Oxygen mg/L	9·1	7·3	6·9	6·7	6·6	8·9	8·7	8·2	8·4	7·4
,, per cent saturation	119	94	88	85	83	114	110	104	106	93
8 Chlorides mg/L	..	..	..	..	..	..	..	..	..	..
9 Silicates mg/L	..	..	..	..	..	..	..	..	..	..
10 Phosphate mg/L	..	..	..	..	..	..	..	..	..	..
11 Hardness (CaCO3) P.P.M.	..	..	..	..	..	..	..	..	..	..

	12th July 1958. 11·00 hours.					"Pannavadi area" 12th July 1958, 8·45 a.m.			
	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
1 Temperature °C	28·8	27·8	27·0	23·7	26·3	26·7	26·4	26·4	26·4
2 Depth m.	0·0	5·0	10·0	15.0	20·0	0·0	6·0	12·0	17·0
3 Free CO_2 mg/L	0·0	0·0	0·0	1·0	1·0	0·0	0·0	1·43	1·43
4 CO_2 mg/L	18·0	15·0	3·0	0·0	0·0	18·0	3·0	0·0	0·0
5 HCO_3	103·7	94·55	91·55	88·45	94·55	88·45	71·00	57·95	79·3
6 pH	8·7	8·4	7·6	7·4	7·4	8·4	7·5	7·5	7·4
7 Dissolved Oxygen mg/L	7·4	6·5	6·6	6·7	6·2	8·9	8·7	8·2	8·0
per cent saturation	97	84	84	88	78	113	110	103	101
8 Chlorides mg/L	..	..	..	..	..	..	..	..	..
9 Silicates mg/L	..	..	..	..	..	Nil	..	.	Nil
10 Phosphate mg/L	..	..	..	..	..	Nil	.	..	Nil
11 **Hardness ($CaCO_3$) P.P.M** ..	..	..	..	..	..	..	.		..

TABLE VI.

(1)	13th May 1962.				*Hogainakal (Cauvery River) 15th May 1962.*			
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1 Temperature °C	32·0	31·4	30·9	30·8	30·8	30·6	30·0	28·8
2 Depth m.	0·0	1·0	3·0	6·0	9·0	12·0	15·0	Surface.
3 Free CO_2 : mg/L	0·0	0·0	0·0	0·0	0·0	0·0	0·0	3·96
4 CO_3 mg/L	27·0	33·0	21·0	18·0	15·0	9·0	0·0	Nil.
5 HCO_3 mg /L	88·5	73·2	103·7	106·3	118·9	128·1	140·0	137·2
6 pH	8·8	8·9	8·8	8·6	8·5	8·4	0·0	7·5
7 Dissolved Oxygen mg/L	10·1	8·5	7·2	7·0	4·4	4·4	0·0	9·4
(per cent saturation)	138	115	97	94	59	59	5·3	110
8 Chlorides mg/L	18·0	..	..	..	..	..	..	20·0
9 Silicates mg/L..	16·0	..	..	..	..	..	..	Turbid.
10 Phosphate mg/L	0·06	0·068	0·06	0·06	0·06	0·06	0·06	0·02
11 Hardness (Ca Co 3) P. P. M.	..	112·0	..	..	114·0	..	..	..

TABLE VII.

	Stanely Reservoir.								
	9·00 hrs.		14th October 1962.				15·00 *hrs.*		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1 Temperature °C	28·8	27·7	25·6	25·4	30·6	28·8	27·2	26·9	26·9
2 Depth m.	0	5	15	25	0	5	15	20	25
3 Free CO_2 : mg /L	0·0	1·21	1·32	1·87	0·0	0·0	1·32	—	1·98
4 Co_3 mg/L	21·0	0·0	0·0	0·0	27·0	12·0	0·0	...	0·0
5 HCO_3 mg/L	42·8	100·7	103·7	97·6	33·55	61·	85·88	—	85·4
6 pH.	8·8	7·4	7·4	7·3	9·1	8·0	7·5	..	7·4
7 Dissolved Oxygen mg/L	9·9	7·0	6·8	6·8	22·9	8·4	6·8	6·8	6·8
per cent Saturation	129	90	85	84	173	110	87	86	86
8 Chlorides mg/L	..	..	..	..	..	..	..	..	..
9 Silicates mg/L	..	..	..	..	..	..	..	..	..
10 Phosphate P mg/L	..	..	..	..	..	..	..	..	..
11 Hardness (Ca Co_3) P. P. M.	..	..	..	..	..	·	..	..	..

TABLE VIII.

	21st January 1963.				
(1)	(2)	(3)	(4)	(5)	(6)
Temperature °C	25·2	25·2	24·8	24·8	24·6
2 Depth m.	0	5	15	20	30
3 Free CO_2; mg/L	Nil	Nil	Nil	Nil	Nil
4 Co_3 mg/L	21·6	14·4	4·8	1·44	0·9
5 HCO_3 mg/L	115·9	137·8	151·3	156·9	177·5
6 pH.	8·8	8·4	7·4	7·4	7·4
7 Dissolved Oxygen mg/L	·8	8·0	5·0	4·6	3·4
Dissolved per cent of saturation ..	..	..	..	..	..
8 Chlorides mg/L	9·0	..	..	..	..
9 Silicate mg /L .. .. .. —	12·0	..	..	..	..
0 Phosphate mg/L .. .. .. —	Nil.	(Total P — 3·2 P.P.M.		—	—
1 Hardness ($CaCO_3$) P.P.M.	60·0	..	—	—	—

TABLE IX.

Stanley.

(1)	8·15 (2)	7th March 1963. (3)	(4)	(5)	(6)	28th March 1963. (7)	(8)	(9)	(10)	29th April 1963. (11)	(12)	(13)	(14)
1 Temperature °C ..	26·2	26·0	26·0	25·4	25·0	30·2	29·2	29·0	28·2	28·0	28·4	28·4	28·
2 Depth m.	0	2	5	10	11	0	1	3	5	8	..	3	6
3 Free CO 2 mg/1 ..	Nil.	Nil.	Nil.	Nil.	3·1	Nil.	Nil.	Nil.	Nil.	Nil.	3·0	2·4	3·0
4 Phenolphthalein alkalinity. mg/L.	15·0	15·0	18·0	2·0	..	8·5	15·0	9·0	2·0	2·0	Nil.	Nil.	Nil.
5 M.O. Alk. mg/L ..	120·0	120·0	116·0	150·0	158·0	55·5	45·0	56·0	72·0	78·0	150	152	158
6 PH	8·8	8·7	8·7	7·6	7·3	7·8	8·8	7·9	7·4	7·8	7·5	7·5	7·5
7 D.O. mg/L ..	8·0	8·0	7·6	3·0	0·6	8·4	8·2	5·8	5·0	2·8	2·4	1·8	0·8
8 Chloride mg/1 ..	20·0	19·0	20	20·0	20·0	..	..	..	..	..	24·2	26·2	23·8
9 Silicate mg/1 ..	17·5	..	..	..	..	..	..	..	..	..	16·4	16·4	16·4
10 Phosphate mg/L ..	Nil.	..	..	..	..	..	..	..	..	..	Nil.	Nil.	Nil.
11 Hardness mg/L ..	66·0	..	..	..	..	..	..	..	..	..	140	..	132
12 E.C. mho	..	..	..	..	..	250	..	..	..	275	300	..	300

TABLE X.

(1)	9th May 1963. (2)	(3)	17th April 1964 *Hogainakal Mettur Dam below Cauvery bridge.* (4)	(5)	5th May 1964 *Jadarpalayam cauvery* (6)	*Pallipalayam railway bridge.* (7)	6th May 1964 *Bhavani cauvery.* (8)	4th December 1963 (9)	(10)	(11)	(12)	(13)
1 Temperature°C	31·4	30·4	0	0	31·8	34·0	..	26·6	26·6	26·6	26·6	26·4
2 Depth m.	0	11	0	0	0	0	0	0	4	8	12	16
3 Free CO 2 mg/1	0·0	3·4	0·0	0·0	0·0	0·0	0·0	0	0·0	0	0·0	0·0
4 Phenolphthalein alkalinity mg/L.	2·0	0·0	12·0	19·0	10·0	13·0	20·0	16·0	16·0	16·0	14·0	16·0
5 M.O. alk. mg/L	145	151	309·0	296·0	286·0	278·0	344	206	206	214	208	204
6 PH	7·5	7·4	8·3	8·3	8·2	8·7	8·5	8·5	8·5	8·5	8·5	8·5
7 mg/1	2·8	0·4	6·4	6·8	5·8	7·4	7·6	7·4	7·4	7·4	7·4	6·8
8 %Sat	..	..	..	..	..	..	..	..	..	..	..	..
9 Chloride mg/L	32·0	..	22·0	23·0	..	..	..	24·0	..	..	..	24·0
10 Sio2 mg/L	18·0	..	4·0	0.0	07	..	..	Tr.	..	..	..	Tr.
11 Phosphate mg/L	..	..	0·0	0·0	0·0	..	..	..	..	..	..	Nil.
12 Hardness mg/L	110	..	124	122	..	..	..	86	..	..	..	86
13 E.C. mho	..	..	290	290	300	300	300	230	..	..	..	225

TABLE XI.

(1)	3rd *January* 1964. (2)	(3)	(4)	23rd *March* 1964. (5)	(6)	(7)	30*th September* 1964. (8)	(9)	(10)	25*th January* 1965. (11)	(12)	(13)	(14)	(12)
1 Temperature °C	26·2	25·8	25·3	25·3	28·3	28·0	27·8	27·8	29·2	25·2	25·1	25·1	2·52	25·5
2 Depth	0	3	6	9	0	1	3	4	0 0	0	5	10	15	20
3 Free CO_2 mg/L	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	..	..	..	0·0
4 P. Alk. mg/L..	32·0	26·0	20·0	5·0	21	13	14	11	6·0	27	21	20	14	6·0
5 M.O. mg/L	236·0	248	260	290	278	294	300	303	6·30	146	160	160	176	201
6 P.H.	8·8	8·7	8·5	8·3	8·3	8·3	8.3	8·1	7·5	8·2	8·1	8·2	7·55	7·3
7 D.O. mg/L	9·6	9·0	6·0	2·6	5·0	4·8	4·8	4·8	6·0	7·4	7·4	6·8	4·2	3·0
8 Cl mg/L	20·0	..	..	22·5	..	..	..	..	10·0	37·0	..	..	..	36·0
9 SiO_3 mg/L	..	..	..	..	0·3	..	..	0·0	1·7	1·6	..	..	..	2·4
10 Phosphate mg/L	..	..	..	..	0·0	..	..	0·0	0·0	0·0	..	..	..	Tr.
11 Hardness mg/L	125	..	..	120	128	..	..	122	50·0	98	..	..	..	106
12 E.C.μ mho	290	..	..	290	300	..	..	290	130	275	..	..	..	275

TABLE XII.

(1)	29*th April* 1965. (2)	(3)	(4)	27*th April* 1965. *Hogainakal.* (5)	(6)	(7)	10*th July* 1965. (8)	(9)	(10)	(11)	(12)	(13)
Temperature °C	29·0	29·0	28·8	28·7	32·0	28·0	27·8	28·4	28·5	28·5	27·8	27·8
Depth m.	0	2	5	10	0	15	19	0	2	5	9	13
Free Co_2 mg/L	0·0	..	..	0·0	0.0	..	..	..	..	..	..	..
P. Alak. mg/L..	12·5	12·5	10·0	7·5	7·0	1·0	1·0	38	39	31	20	13
M.O. Alk. mg/L	125·0	125·5	12·00	137·5	154·0	156	156	158	151	163	157	168
PH	8·5	8·5	8·5	8·4	8·4	8·2	8·1	8·8	8·8	8·8	8·0	8·0
D.O. mg./L	6·4	6·8	5·8	4·2	7·6	0·2	0·1	9·6	9.6	8·6	6·2	6·0
Cl mg/L	22·0	..	..	..	13·4	..	(River 6·4 si)	19·0	..	..	..	..
Hardness mg/L	114·0	..	..	..	126·0	..	..	95·0	..	..	..	..
SiO_2 mg/L	34	..	..	..	1·2	..	..	2·0	..	..	..	..
Phosphate mg/L	0·001	..	..	..	0·0	..	..	0·0	..	..	..	..
E.C.μ mho	350	..	..	..	..	..	350	210	..	..	..	..

PRAWN CULTURE AT THE BRACKISHWATER FISH FARM ADYAR, MADRAS.

Thirumathi GEMMA EVANGELINE, M.A., Assistant Director of Fisheries (Marine Biology), Madras-6.

Introduction.

Rapid strides are being made in the development of the prawn export industry in India. One faces today the necessity to perpetuate the shrimp resources of the country and counteract the steady exploitation of shrimp stock. A survey of the prawn resources and biological and cultural studies of the prawns of economic importance in India, are the guide lines on which planned development and management of the prawn fishery resources can be co-ordinated with national exploitation.

For the last two decades, interested research workers in various parts of India, have been delving into the mysteries of the bionomics and fishery of both Penaeid and Non-Penaeid prawns that occur as a commercial fishery on the east and west coasts of India, in West Bengal, Orissa, Andhra, Maharashtra and Gujarat.

Panikkar (1937), (1959), Menon (1951), (1952), (1953), (1955), (1957). Panikkar and Menon (1955), Menon and Raman 1961, and George (1959), (1960), (1961), (1962) have done extensive work on growth, length of life, sex ratio, migration and fishery of the prawns of the Malabar Coast. Chopra (1939), Rai (1933) and Shaik Mahmud and Tembe (1960) have made similar studies on species occuring at Bombay. Rajyalakshmi, (1961) and Subrahmanyam (1966) have studied the biology and fishery of prawn species in the estuarine system of West Bengal. Chacko (1955) give us an account of the prawn fisheries of the Madras State, while Subrahmanyam (1963), has worked on the reproductive cycle and development of Penaeus indicus from the Madras coast.

Very little attention has been paid to the farming of prawns in brackishwater ponds. Menon (1951) has conducted some rearing experiments in the laboratory. In 1955, investigations were made by him in the Narakkal farm with special reference to paddy field prawn culture. Gopinath (1955) similarly studied prawn culture in the rice fields of Travancore-Cochin. George (1961) conducted experiments twice in a small section of the prawn farm at Narakkal to study the growth rate of Metapenaeus monoceros.

Studies on prawn farming in the estuarine fish farm at Adyar were begun as early as May 1959 and are being continued. This paper deals with observations made in the Adyar estuary and connected reservoir, stock ponds, rearing ponds, nurseries and marketing ponds that cover an area of 55·4 acres.

Observations.

1. *Availability.*—Adults of the freshwater prawn, Palaemon idae are washed down into the estuary along with the monsoonic freshwater floods in October, November, December. They thrive in the estuary and breed there but do not form a commercial fishery of considerable magnitude.

Post larvae of the marine prawns Penaeus indicus (Milne Edwards) Penaeus carinatus (Dana) Metapenaeus monoceros (Fabricius) and Metapenaeus dobsoni (Miers) enter the estuary when they are six millimetres to ten millimetres in length. The sand bar of the Adyar river opens up anytime between August and November every year, depending on the strength of the freshwater floods that flow down the river with the onset of the North East monsoon. Table 1 gives details of the opening and closing of the bar in the different years and tables 2 to 6 the meteorological variations in the different years.

The post larvae of marine penaeids are found to change their planktonic mode of life to a demersal one when they enter the estuary. Stray post larvae are available in the plankton whereas thousands can be collected from the bottom in the shallows. Post larvae are totally absent before the opening of the bar. They put in a miraculous appearance five to twelve days or sometimes even after a month from the time of the opening of the bar, the length of time depending on the access of tides into the estuary and the abatement of freshwater flood waters. Thus it is observed that the bar opened on 21st October 1963 and larvae were recorded from 25th October 1963 to 9th January 1964 at which time the bar closed. Similarly the bar opened on 5th September 1964 and larvae were noticed on 17th September 1964 twelve days after the opening and continued to be available, till the closing of the bar on 30th January 1965. In 1965 the bar opened on 17th November 1965 and larvae started appearing only after 15th December 1965, nearly a month later. The availability of larval *Penaeus indicus* and *Penaeus carinatus* between January 1960 and June 61 are given in table 35.

Variations are found from year to year in the percentage composition of the four species that contribute to the prawn fishery of estuary. Penaeus indicus forms 35 to 100 per cent of the total prawn catches. *Metapenaeus monoceros* forms 1 to 17 per cent of the whole and *Penaeus carinatus* forms only 0.5 to 16 per cent of the total catch. *Metapenaeus dobsoni* forms 1 to 75 per cent. Comparison of tables 36 and 37 show however that, Penaeus indicus is the predominant species.

Table 39 in which a random sample of 3176 specimens of prawns have been examined in 1964-65 confirms the fact that *Penaeus indicus* is the predominant species as 2320 numbers were Penaeus indicus. while only 662 were Metapenaeus dobsoni, 119 Metapenaeus monoceros and 75 Penaeus carinatus. There are however certain seasons or periods when certain of the species are abundant or available in larger quantities than usual. Thus Penaeus indicus is abundant in November, December, March and April. Metapenaeus dobsoni appears in large numbers in January and February. Metapenaeus monoceros is common in December, March and April. Penaeus carinatus is common in March, April November and December. Slight variations occur with variations in meteorological and hydrological conditions from year to year. Tables 22 to 28 give the variations in salinity, pH, oxygen contents and the like in the Adyar river, while tables 15 to 21 give the variations in the reservoir and tables 8 to 14 that in one of the culture ponds. Table 29 gives a comparative statement of conditions in the ponds of the Estuarine Fish Farm, the Reservoir, river and nurseries. Salinity, pH and Oxygen contents are at their lowest between October and December when heavy rain and floods have opened the bar facilitating the entry of prawn larvae. Salinity, pH and oxygen contents are at their highest just at the time of the closure of the bar between April and June. Water temperature is highest at this period and is at its lowest in October, November and December, paralleling the increase and decrease in Salinity, pH and oxygen. Depth also shows similar variation, low depth being noticed between January and March and high depths between August and October.

2. *Collection.*—The larvae ascend the river and creek to a distance of half to one mile upstream. During the peak periods of occurrance large congregations are found at the sluice gates of the regulator and at the shutters of the ponds which open into the reservoir. They can be baled out in bucketfuls at this time and transferred to the culture ponds with little effort. Large numbers enter the ponds through the cracks and crevices in the shutters of the pond inlets even without lifting of the shutter and still larger numbers could be got into the ponds by appropriate opening and closing of the pond shutters during the peak seasons.

Artificial collection and stocking is found necessary in ponds situated **a mile** away from the mouth of the river. Post larvae are best collected from the shallows of the river in rectangular pieces of velon used as hand cloth. Six to ten milimetre sizes are very suitable for collection and stocking, and mortality is nil when such sizes are collected in the early morning hours and transported in tin carriers to the culture ponds. Mortality rate is found to increase as the size increase and during the later hours of the day when temperature also increases.

3. *Stocking.*—Natural stocking by operation of the pond shutters is very effective for mixed culture of prawns of various species provided the pond is first cleared of predator fish such as *Serranus* species, *Therapon jarbua, Elops indicus, Megalops cyprinoides* and *Lates calcarifer.* Rearing of the larvae in nurseries and rearing ponds is necessary when large growing species such as *Penaeus indicus* are to be segregated for separate culture or species occuring in small numbers such as *Penaeus carinatus* have to be collected in considerable numbers for monocultures. It is also a method to eliminate small growing species such as *Metapenaeus dobsoni* which occur in considerable numbers and compete for food and space with the larger, abundant, and more long lived species such as *Penaeus indicus.*

The fry have to be transferred from the small nurseries to the larger rearing ponds when they are 50 to 75 mm. long and 0·5 gms. to 1·5 gms. in weight. Transference to the culture ponds is done at the close of the second month when they are 90 mm. to 110 mm. long and 3 to 6 grs. in weight. A certain percentage of mortality is met with at every stage of transference particularly with *Penaeus indicus* and *Metapenaeus dobsoni* but is not so high with *Metapenaeus monoceros* and *Penaeus carinatus* which easily survive netting and handling and can be kept even out of water for a few minutes without fear of mortality. Natural stocking eliminates the laborious process of collection and transference thrice from collection grounds to nurseries, from nurseries to rearing ponds and finally from rearing ponds to the culture ponds and minimises mortality. Fifty per cent is lost in such transference both in the case of *Penaeus indicus* and *Metapenaeus dobsoni*.

4. *Food and Feeding.*—A study of the stomach contents of the four different species of prawns at various size groups show the food taken to be common for all the species and is more or less similar for all size groups. Tables 45 to 48 show the major food items included in the diet. *Penaeus carinatus* shows a preference for filamentous algae. Sand grains are hardly ever absent indicating the bottom browsing tendency of prawns. The presence of Foraminiferans, Lamellibranchs, Gastropods, Cyprids, fish scales and blue green algae in the stomach contents lend support to this. However they are plankton feeders also and forms like Copepods, Daphnids, Peridinium and Diatoms cannot be missed. Their carnivorous propensities are revealed by the presence of chitinous parts of insects and crustaceans.

Under laboratory conditions they reveal a craze both for Polychaetes and earthworms. Boiled rice, rice bran, cotton seed meal and oil cakes mixed and supplied to them in small pellets are relished when choice foods are absent. They turn cannibalistic when starved and feed on their own kith and kin. Their own exuviates are consumed voraciously soon after moulting. On the whole, they are voracious feeders in the fry and juvenile stages, this being necessary for quick and good growth.

5. *Growth.*—Growth of prawns in the natural estuarine conditions, in the estuarine ponds and in aquarium conditions have been studied carefully over several years.

(*a*) *In aquarium conditions.*—Observations show that this is extremely poor in comparison with growth in natural conditions. On 27th November 1963 twenty-five post larvae and fry of size range 18 mm. to 47 mm. with weights ranging from a fraction of a gram to one gram were put into a circular cement cistern of three feet diameter and their growth watched. In March 1964 they measured 43 mm. to 84 mm. in length and weighed 1 to 2 grams, the increase in length for a period of four months being 35 to 37 mm. and the increase in weight being approximately one gram. Only forty per cent survived.

Similar observations were made in 1964. Post larvae 15 mm. to 30 mm. size range were recorded in the estuary on 19th September 1964. Eleven days later, i.e. on 30th September 1964, 15 mm. to 60 mm. size groups were recorded showing that the 30 mm., sizes had grown further by 30 mm. Post larvae 10 mm. to 15 mm., collected on 17th September 1964 were reared in rectangular glass aquaria 3 feet by one and half feet by one and half feet in dimensions. About fifty numbers were put in each of four such aquaria. Size range after thirteen days was 15 mm. to 20 mm. growth being only as low as 5 mm. A month later, a size range of 20 mm. to 30 mm. was found, increase in length being only as much as 5 mm. to 10 mm. whereas the estuarine prawns were in sizes of 36 mm. to 110 mm., the increase in length varying from 20 mm. to 50 mm. Very little increase in length and weight was found in the aquarium prawns. Even after six months. their lengths did not exceed 75 mm. and their weights 2 grams. 50 to 75 per cent mortality was noticed.

Moulting was noticed once in fifteen to twenty days and sometimes longer. Moulting was observed just after a spell of heavy feeding or after rough or frequent handling. It took place invariably in the early hours of the morning when the rostrum with carapace was thrown off as one piece and the head, thoracic appendage, abdomen, abdominal appendages and telson came off as another separate whole. Individuals were found to dig pits in the sand placed at the bottom of the aquaria with the help of their walking legs soon after the process of moulting. They bury themselves in these pits, the swimmerets being used as shovels to push the sand over so as to cover their backs and form small mounds. Only the eyes with their eye stalks could be seen emerging above the sand and that too after careful observation and with much experience. During this period they did not come out for feeding during the day in spite of luring food such as chopped, live polychaete worms. The food was however found to disappear by the next morning which probably meant that they feed in the dark hours during this phase. They were normally found to bury from only one to three days after moulting but were sometimes found to live under the bottom soil for more than a month feeding regularly at nights. Very often the exuviates were eaten by other prawns in the same aquarium.

Tagging of these prawns to study the period of moulting was done with tiny coloured glass beads and fine nylon threads. One tag with beads of a certain colour was stitched on laterally to the hind end of the cephalothorax where it covered the branchiae and was tied fast. Another thread with the same colour and number of beads was tied loosely round the middle of the body of the prawn between the juncture of its cephalothorax and abdomen. During moulting the beads attached to the carapace with rostrum were thrown off indicating that one particular prawn had moulted. The other set of beads tied round the body remained intact, the moult of the head and walking legs coming off as one piece and that of the abdomen and telson coming off as a separate piece, making it possible to identify the particular prawn which had thrown off beads of a particular colour and number. Similar tagging of prawns in the brackishwater ponds was tried successfully and was helpful with regard to the study of individual growth, ecdysis and migration.

(b) In Estuarine Conditions—(1) Penaeus indicus 1959-60.—Table 39 shows the size ranges of *Penaeus indicus* available in the estuary between June 1959 and May 1960. The post larvae appear at a size of 5 mm. and have probably entered in October 1959 soon after the opening of the bar. Fry 24 mm. to 72 mm. in size range were recorded in November 1959. Predominant size groups ranged from 39 mm. to 48 mm. In December 1959 the size ranges were from 46 mm. to 83 mm. with the predominant size groups being from 50 to 60 mm. The presence of the 46 mm. sizes indicate an entrance of post larvae again in November 1959. Growth in the predominant size groups which are in the second month after their appearance in the estuary is only by 11 mm. to 12 mm. In January 1960 the third month after their entry the size range available is 63 mm. to 98 mm. with predominant sizes in the groups 97 mm.-98 mm. and 75 mm.-76 mm. Increase in length is very high being as much as 25 mm. to 38 mm. Size range in the fourth month, i.e., February 1960 is from 78 mm. to 111 mm. the predominant sizes being 92 mm. and 111 mm. Growth is only by 13 mm. to 17 mm. In March 1960 the fifth month a size range of 67 mm. to 129 mm. is available with the predominant sizes being 87 mm., 117 mm., 118 mm. and 129 mm. showing two different stocks the smaller sizes being stock that entered about January 1960. The original stock have increased in length by 18 mm. to 26 mm. In April 1960 the sixth month, a third entry of prawn larvae is indicated by the presence of sizes ranging from 22 mm. to 105 mm. The original stock is found missing while predominant size groups belong to the third and fourth stock that entered and range from 65 mm. to 68 mm., 99 mm. and 100 mm. In May 1960 the seventh month after the entry of the first stock, since the opening of the bar, size ranged from 122 mm. to 144 mm. predominant sizes being 127 mm., 128 mm. and 134 mm. to 135 mm. These in all probability are the absent members of the first two stocks which were probably hibernating during the previous month due to unfavourable conditions such as high water temperature vide Table 2 and, have come out of their hide outs in May 1960, the following month when water temperature has dropped from 31 ° C to 30·5 ° C. The largest sizes recorded in 1959 are 136 mm. in July 1959 and in 1960 are 144 mm. in May 1960 roughly seven to eight months after the first entry of prawn larvae consequent on the opening of the bar.

1960-61.—The bar opened on 2nd October 1960. Vide Table 1. Larvae entered in October 1960 itself. They were found to have grown from a size range of 5 mm. to 10 mm. in October 1960. Increase in length in the first month, is by 25 mm. to 61 mm. In December 1960. 78 mm. to 102 mm. sizes were recorded, increase in length in the second month being by 19 mm. to 48 mm. and which is less than in the first month. In January 1961 sizes recorded ranged from 50 mm. to 120 mm. this being the third month. Increase in length is found to vary between 1 mm. and 18 mm. The small sizes are of fresh stock that entered in December 1960. In February 1961, the fourth month 72 mm. to 140 mm. size groups were recorded, increase in length being 20 mm. to 22 mm. A new stock is found to enter again in February 1961 and again small size groups are recorded in March 1961 the size range being 54 mm. to 100 mm. The bar closed on 29th May 1961 and a fresh entry was noticed in May 1961 and this contributed to size groups of 50 mm. to 102 mm. in June 1961 which grew to the 85 mm. to 111 mm. size groups the fourth month, after the second entry in March 1961. This growth is similar to the growth of the first stock in the fourth month in 1959-60. Similar size groups were noticed in August 1961, size range being 76 mm. to 115 mm, the smaller sizes being of those that entered in April 1961. The bar opened on 5th August 1961 and post larvae appeared in abundance by the middle of the month.

The largest size recorded in 1961 is 140 mm. and this was reached even in the fourth month after the opening of the bar.

1962-63.—The bar opened on 23rd August 1962 and prawn post larvae appeared in September 1962. They had grown to a size range, of 78 mm. to 90 mm. in December 1962 the third month. By March 1963, the sixth month 60 mm. to 130 mm. size groups were available showing that there had been a second entry of larvae in January 1963. In April 1963 the seventh month small sizes were again available indicating a third entry in February 1963. Length range was 55 mm. to 124 mm. and weight range 0·25 grams to 10 grams. In May 1963, the eighth month, size groups ranging from 53 mm. to 142 mm. were recorded indicating another entry of larvae in March 1963 and growth of the January stock to their maximum of 142 mm. in the fourth month. Weight range was 0·25 grams to 25 grams and the predominant size groups ranged from 75 mm. to 90 mm. The bar closed on 4th May 1963 but prwns continued to be available in large numbers till July 1963. They dwindled down in numbers between August and October 1963. 66 mm. to 117 mm. size groups with weight ranges of 1·5 grams to 21 grams were recorded in June 1963. 66 mm. to 125 mm. size groups with weight ranges of 13 grams to 25 grams were recorded in July 1963. 68 mm. to 135 mm. size groups with a weight range of 16 grams to 30 grams were recorded in August 1963. 105 mm. to 140 mm. size groups with a weight range of 24 grams to 35 grams were recorded in September 1963.

The maximum length recorded in 1963 was 140 mm. with a maximum weight of 35 grams.

1963-64.—The bar opened on 21st October 1963 and post larvae 15 mm. in length were captured in the planktonic haul even as early as 24th October 1963. The bar closed again on 27th October 1963 but opened soon after on 5th November 1963. Size range of prawns collected in November 1963 were from 56 mm. to 88 mm. with a weight range of 0·8 grams to 2·5 grams. Post larvae 5 mm. to 10 mm. in size, were also available in November 1963 so that, the size groups available in December 1963 ranged from 12 mm. to 38 mm. and were abundant. Entry of larvae continued in December 1963 and January 1964. Size ranges available in January 1964 were 18 mm. to 123 mm. with weight ranges of 0·25 grams to 12·5 grams. The bar closed on 9th January 1964 and larger size groups were available from February 1964 onwards. In February 1964 the fourth month after the first entry the largest sizes were 116 mm. and the smallest sizes 64 mm. Weight range was 2 grams to 11 grams. Similar size ranges were found till May 1964. The prawns of the first entry 91 mm. to 115 mm. in length however weighed between 18 grams and 21·5 grams in March 1964 and were as much as 32 grams in April 1964 the sixth month, for a maximum length of 138 mm. Sizes ranged between 104 mm. and 130 mm. in May, June and July 1964 with a weight range of 23 grams to 36 grams as there had been continuous entry from October 1963 to January 1964. By August 1964 individuals 132 mm. to 146 mm. were available with weight ranges of 31·0 grams to 42·5 grams.

Maximum length recorded for 1964 was 146 mm. with a maximum weight of 42·5 grams.

1964-65.—The bar opened on 5th September 1964. Post larvae of sizes 15 mm. to 30 mm. were collected on 19th September 1964 and sizes of 15 mm. to 60 mm. were collected eleven days later on 30th September 1964, showing an increase in length of 30 mm. in the 30 mm. individuals of 19th September 1964. In October 1964, a month since the first appearance in the estuary, 36 to 110 mm. sizes were available weighing 0·36 grams to 3·7 grams. 60 mm. size had increased in length by 50 mm. In November 1964, the second month after their appearance, size groups ranging between 41 mm. and 115 mm. weighing 1·4 grams to 6 grams were available. A second entry in October 1964 has resulted in the appearance of 41 mm. sizes. Increase in the larger size groups is only by 5 mm. in length but as much as 2·3 grams in weight. In December 1964 the third month after their appearance the length range recorded was 70 mm. to 122 mm. and their weight range 3·2 grams to 6·5 grams. An increase in length of 10 mm. was noticed in the larger size groups while the increase in weight was only 0·9 grams. In January 1965, the fourth month after their appearance, size groups available ranged from 36 mm. and 132 mm. with weights ranging from 0·43 grams to 15 grams. The smallest size groups belong to a second entry of larvae in December 1964 and have grown by 20 mm. to 50 mm. in length. The largest size groups are found to have increased in length by 10 mm. which is more or less normal where as the increase in weight is by 8·5 grams and is exceptional. In February 1965 the fifth month since the first appearance, size groups available ranged from 46 mm. to 159 mm. with weights ranging from 1·4 grams to 29·5 grams. The smallest size groups are from fresh stocks of larvae that entered in January 1965, the bar having closed on 30th January 1965. The largest size groups have increased in length by 27 mm. and in weight by 14·5 grams. In March 1965 the sixth month since the opening of the bar in September 1964, the size groups available were 88 mm. to 155 mm. with weights ranging from 8 grams to 22 grams. Growth in length and weight has not progressed over the maximum length and weight of 159 mm. and 29·5 grams recorded in February 1965 the fifth month. In April 1965, the seventh month, size groups available ranged from 68 mm. to 141 mm. with weights ranging from 3 grams to 15 grams. Maximum length and weight is found to be considerably less than in the previous month. Penaeus indicus was absent from May 1965 till the opening of the bar on 17th November 1965. Although the bar closed on 30th January 1965, prawns were available for three months after, dwindling in numbers in March and April 1965.

(2) Penaeus carinatusu—1959-60.—These appeared in the estuary at sizes of 6 mm. to 15 mm. when the bar opened in October 1959. By November 1959 they had grown to sizes of 37 mm. to 56 mm., increase in length ranging from 31 mm. to 41 mm. By December 1959, sizes available ranged from 46 mm. to 61 mm. the increase in length being between 5 mm. and 9 mm. Few individuals of the 95 mm. size groups were available in January, increase in length being by about 34 mm. In February 1960, Penaeus carinatus were absent. In March 1960 few individuals of the 65 mm. size group were available indicating a second entry of post larvae two months earlier, i.e., in January 1960. Again, individuals were absent in April 1960 while 65 mm. sizes were again available in May 1960 indicating a third entry of post larvae in March 1960. The largest size of Penaeus carinatus recorded in 1959 was 130 mm. in the month of October 1959. This could easily belong to stock that entered in March 1959 and would be about seven months old.

1960-61.—The bar opened on 2nd October 1960. Post larvae entered almost immediately. By the end of October 1960, 41 mm. to 59 mm. size groups were available revealing the quick growth of the larvae in the first month. Larvae continued to enter in November 1960. The larvae that however entered first had reached the 80 mm. and 81 mm. size groups, increase in length being 21 mm. to 22 mm. 94 mm. size groups were available in December 1960 increase in length being 10 mm. New stocks seem to have entered in December 1960 and 70 mm. size groups were again available in January 1961. Fresh stocks of post larvae continued to appear in January 1961 also. Size groups available in February 1961 ranged from 90 mm. to 117 mm., those of the larger size groups being that which entered in October 1967. Large specimens of Penaeus carinatus of size range 135 mm. to 191 mm. and weight range 24 grams to 64 grams were also available in the estuarine catches in February 1961. They probably belonged to the stock of the previous year 1960 and were atleast ten months old. 95 mm. to 134 mm. size groups continued to be available in March 1961 side by side with 212 mm. to 225 mm. size groups of the last years stock which continued to appear in April and May 1961 also. The bar closed on 29th May 1961 after which Penaeus carinatus was rare.

The maximum size attained by the 1960 stock in five months was 134 mm. weight reached being 21 grams.

1962-63.—The post larvae entered in September 1962. The bar opening on 23rd August 1962. Five months later, i.e., in January 1963 they had attained a size range of 60 mm. to 100 mm. new stock entering in October and November 1962. In March, sizes ranged from 75 mm. to 130 mm. new stock having entered in large numbers in January 1963. In April 1963, large sizes 160 mm. to 174 mm. in length and 29 grams to 39 grams in weight were available. The bar closed on 4th May 1963. The sizes avilable ranged from 100 mm. to 166 mm. with a weight range of 8 grams to 37 grams. In June 1963 Penaeus carinatus of size range 75 mm. to 120 mm. were recorded the smaller sizes being those that entered shortly before the closure of the bar. Weight range was 11·5 grams to 18 grams. In July 1963, 88 mm. to 188 mm. sizes with weight ranges of 16 grams to 75 grams were available the large ones belonging to the previous years stock and not that of 1962-63. Penaeus carinatus was rare in

August and September 1963. The largest recorded for the year was 166 mm. with a weight of 37 grams and was about eight months old.

1963-64.—The bar opened on 21st October 1963 and larvae started entering by 24th October 1963. The bar closed again on 27th October 1963, but opened soon after on 5th November 1963. Teeming millions of prawn larvae including that of Penaeus carinatus entered again. Those that entered in October 1963 had grown to a size of 34 mm. to 71 mm. More post larvae were found to enter in not only in November 1963 but also in December 1963. Common sizes ranged from 29 mm. to 40 mm. In January 1964 size ranged from 32 mm. to 142 mm. the first larvae having grown from 35 mm. to 71 mm. in three months. Weights ranged from a fraction of a gram for larvae that just entered to 20 grams for the maximum sizes which were rare. 12 grams or 13 grams was the weight of the 117 mm. to 121 mm. size groups which were common. Larval stock were also found to enter. In February 1964 larvae still entered and 40 mm. to 160 mm. size groups were recorded with weights ranging from a fraction to 31 grams. This was the fourth month since the first entry was recorded in 1963. In March 1964, 93 mm. to 198 mm. sizes were found. Weight ranged from 19 grams to 67 grams. Even the smallest sizes of 93 mm. were on the increase in weight while larger ones showed a remarkable increase for the fifth month. In April 1964 sizes ranged from 100 mm. to 158 mm. with weight ranging from 6 grams to 32 grams. In May 1964, the sixth month, a maximum size of 210 mm. with a weight of 96·5 grams were recorded. In June 1964, the common size range was from 121 mm. to 154 mm. with a weight range of 32 grams to 53 grams. In July 1964. length range was 138 mm. to 167 mm. and weight range 33·5 grams to 59 grams. In August 1964 length range was 140 mm. to 185 mm. and weight range 25 grams to 60 grams.

The bar opened on 5th September 1964. While large specimens 141 mm. to 176 mm. in length were available with weights ranging from 34 grams to 55·5 grams, fry 16 mm. to 41 mm. in length were also collected.

1964-65.—While *Penaeus carinatus* was abundant in 1963-64 it was less common in 1964-65. In December 1964, three months after their first appearance, fry of 20 mm. and juveniles ranging from 90 mm. to 100 mm. were recorded. In January 1965, sizes ranged from 85 mm. to 171 mm. with weight range of 5 grams to 43 grams. In February 1965 sizes ranged from 80 mm. to 168 mm. and weights from 9·5 grams to 31 grams. In March 1965 size range available was from 115 mm. to 168 mm. with a weight range of 12 grams to 46 grams. In April 1965 though Penaeus indicus was present, Penaeus carinatus was absent. The bar closed as early as 30th January 1965 and opened again on 17th November 1965. Post larvae were found to appear in the later half of December 1965.

3. *Metapenaeus monoceros.*

1959-60.—The bar opened in October 1959 when new stock entered. In November 1959 sizes available ranged from 26 mm. to 47 mm. In December 1959 sizes available ranged from 42 mm. to 58 mm. Larvae continued to enter till January 1960 and sizes ranging from 19 mm. to 76 mm. were available in January 1960. Individuals were not found in the random samples collected. between February 1960 and April 1960. In May 1960, sizes ranging between 65 mm. and 72 mm. were collected Large individuals were absent after that till the close of the year.

1960-61.—In January 1961 the few larvae that had entered in October 1960 had grown to sizes varying from 34 mm. to 62 mm. with weights ranging from $^1/_2$ gram to 3 grams. Metapenaeus monoceros was rare during the rest of the month and was available again after the bar opened on 5th August 1961. Sizes available ranged from 30 mm. to 72 mm. by the end of August 1961.

1962-63.—The bar opened on 23rd August 1962 but larvae were found to enter in March 1963. Sizes of 49 mm. to 62 mm. were found in May 1963. In July 1963. sizes ranging from 59 mm. to 78 mm. and weighing from half to 4 grams were found. In August 1963, sizes ranging from 65 mm. to 86 mm. with weights ranging from 2·5 grams to 6·5 grams were recorded. Maximum length recorded was 86 mm. with a weight of 6·5 grams.

1963-64.—The bar opened in Novembe 1963. Larvae that entered in December 196 were found to grow to a size range of 27 mm to 45 mm. in January 1964. In February 196 length range was 20 mm. to 114 mm., minimum sizes being those that entered only in January 1964. Weight ranged from 2 grams t 23 grams. In March 1964 sizes availabl ranged from 65 mm. to 119 mm. Weight range from 13·5 grams to 24·5 grams. In April 196 sizes ranged from 72 mm. to 80 mm. an weights 1·5 grams to 3·5 grams. A specime of 170 mm. length and 28 grams was recorded in August 1964. In September 1964 size range was from 82 mm. to 107 mm. In September 1964 the bar opened and larvae entered, sizes of 6 mm. to 27 mm. being available.

1964-65.—In November 1964, 74 mm. size of *Metapenaeus monoceros* were available. In December 1964, 34 mm. to 89 mm. sizes were recorded and were abundant. In January 1965 sizes available ranged from 36 mm. to 92 mm. with weight ranging 2 grams to 6 grams. In February 1965 sizes ranged from 58 mm. to 91 mm. Weight ranged from 2 grams to 6 grams. Individuals were not available from March 1965. The bar opened on 17th November 1965 and an abundance of larvae were available a week after. Fry of 42 mm. to 75 mm. were available in January 1966 and continued to be available in February 1964 also.

4. *Metapenaeus dobsoni.*

1959-60.—New stock entered in October 1959. They were of sizes ranging from 26 mm. to 47 mm. in November 1959. In December 1959 similar sizes were available. In January 1960, they had grown to a size range of 57 mm. to 84 mm. In February 1960, 19 mm. to 69 mm. size groups were available. In February 1960 size groups available ranged from 19 mm. to 82 mm. In March 1960 specimens were not available. In April 1960, 53 mm. to 55 mm. sizes were available and in May 1960, 72 mm. to 77 mm. size groups were available. The maximum size recorded was 84 mm.

1960-61.—Metapenaeus dobsoni was not available during the year.

1962-63.—The bar closed on 15th March 1962, and larvae were found to enter even just before the closing. Size ranges of 72 mm. to 77 mm. were recorded in April 1967. They weighed 2 grams to 2·5 grams. In May 1963, 42 mm. to 72 mm. sizes of one to 2 grams weights were recorded. In July 1963 an abundance of 45 mm. to 59 mm. sizes were found. Largest length recorded was 92 mm. and greatest weight 4·5 grams in October 1963.

1963-64.—Larvae entered in November 1963. 27 mm. to 44 mm. sizes were available during the same month. In January 1964, 24 mm. to 65 mm. size groups were available. Weights ranged from 0·5 to 1 gram. In February 1964, 54 mm. to 70 mm. sizes with weights ranging from 1 to 2 grams were recorded. In March 1964 sizes still remained between 65 mm. and 71 mm., weights ranged between 2 grams and 4 grams. The largest length recorded was 71 mm. with a weight of 4 grams. Individuals were absent till the opening of the bar in **September 1964.**

1964-65.—Size groups ranging from 20 mm. to 27 mm. were available at the end of September 1964. In October 1964, 50 mm. to 78 mm. sizes were available. Weights ranged from 0·5 to 1·5 grams. In November 1964, 54 mm. to 76 mm. sizes were available. Weight ranged from 2 grams to 3 grams. In December 1964, 50 mm. to 61 mm. sizes were available, their weights ranging from 1 gram to 2 grams. In January 1965, 51 mm. to 90 mm. sizes were available, their weights, ranging from 1 to 1½ grams. In February 1965, 46 mm. to 87 mm. sizes were available. Their weights ranged from 1 gram to 2·5 grams. In March 1965 sizes ranged from 68 mm. to 79 mm. and weights ranged from 2 grams to 3 grams. The bar closed on 30th January 1965. Individuals were available only up to March and were again available after the opening of the bar on 17th November 1965. 41 mm. to 43 mm. sizes were available in January 1966.

(c) In the brackish water ponds—1. Penaeus Indicus.—Detailed studies on the growth of *Penaeus indicus* were taken up in one of the stock ponds of the estuarine fish farm, Adyar during the periods December 1960 to December 1961 and March 1963 to March 1964.

On each occasion 5,000 fingerlings were stocked and consisted of 75 per cent of *Penaeus indicus* and 25 per cent of *Penaeus carinatus* in the first instance and 50 per cent *Penaeus indicus*, 40 per cent *Metapenaeus dobsoni* and 10 per cent *Penaeus carinatus* in the second instance. *Metapenaeus monoceros* was not cultured as it was not available in sufficient numbers, but the growth of stray specimens in the ponds was observed.

The entry of larval prawns by natural means was noticed in the ponds during the experiments. The prevention of this entry by closing inlets completely, resulted in the total disappearance within a month of those individuals already stocked as there was no free tidal ingress and egress.

In December 1960, fry and fingerlings of Penaeus indicus of size range 46 mm. to 83 mm. were stocked. The increase in length and weight for females as well as males is given in Table 40. The maximum growth recorded for female *Penaeus indicus* is 189 mm. and 90 grams while that of the male is 185 mm. and 90 grams. A study of the growth, table and graph 1 and 2, along with a study of tables Nos. 35, 36 and 37, which show the occurrence of larvae and fry, indicates that larvae and fry are entering from September of the one year to May of the corresponding year depending on whether the bar opens as early as August on the one hand and closes as late as May on the other. There are degrees of variations in this from year to year depending on the meteorological conditions which though seasonal in their changes are also varied from year to year.

A study of the minimum sizes recorded in 1960-61 show that young prawns have entered into the pond between November 1960 and March 1961 and hence the presence of small sizes ranging from a few millimetres to 95 mm. during that period. A perusal of the maximum sizes show that every fourth month the highest maximum sizes are attained. In the females, 187 mm. is recorded in February 1961 the fourth month since the entry in October 1961. Similarly the second maximum of 182 mm. is noticed in May 1961 the fourth month after the last maximum in February 1961 and which are probably the young ones noticed in January, which have grown to these large sizes in the space of four months. The third maximum of 183 mm. is noticed in August 1961, the fourth of 180 mm. in November 1961 and the maximum of 189 mm. in December 1961, these being the adults of subsequent stocks that entered from time to time during the period the bar remained open. The bar had remained open as late as 29th May 1961 during this year which means that fry would be available even as late as June 1961. Table 35 confirms the presence of larvae till June 1961.

In the males also, a similar regular appearance of maximum sizes every fourth month is noticed. Weights are found to be low in the fingerling stages, i.e., up to 101 mm. to 140 mm. stages. Over this, the weight shoots up to 60 grams between the 140 mm. and 161 mm. stages. Between the 161 mm. and 189 mm. stages the weight goes up further to as much as 90 grams although it is normally between 60 and 70 grams.

The highest maximum length attained by the fry after four months growth is 189 mm. in females and 185 in males, the maximum weight attained in both sexes being 90 grams. The lowest minimum length after four months growth is 125 mm. in females and 122 mm. in males, weight in both sexes being not less than 25 grams. The predominant sizes obtained after a growth of four months ranges from 120 mm. to 140 mm. with a weight range of 25 grams to 40 grams. 170 mm. to 189 mm. size groups are found to disappear after the fourth month. Mortality rate increase which is negligible in the first three months, increases rapidly after the fourth month being about 50 per cent. It increase to 75 per cent by the sixth month and is 90 per cent by the eight month. By the tenth month there is usually cent per cent mortality, one per cent surviving occasionally.

Growth of *Penaeus indicus* as observed in 1963-64 was not as good as in 1960-61. However the fingerlings were available till August 1963 as the bar was open till May 1963 and average sizes from 130 mm. to 147 mm. with weights ranging from 22 grams to 33·5 grams were available every month between May and September 1963 indicating that as larvae have been available every month from January 1963 till the closure of the bar in May 1963, maximum sizes have been available every month from May 1963 to September 1963 continuously and are absent after that due to a disappearance of the large sizes after the fourth month of their growth from the fry stage, the last set of fry entering in May 1963 just before the closure of the bar. It will be noticed that there was cent per cent mortality by October 1963, the tenth month though prawn larvae just started entering in August 1962 after the opening of the bar, the fingerlings of March belong to the stock that entered in January 1963.

2. *Penaeus carinatus*.—The sizes available in January were four months old being 177 mm. in length and 43 grams in weight. Fingerlings range in length from 90 mm. to 120 mm. and attain this length in the third month after the fry stage. Average lengths are attained in the sixth month when the minimum length ranges between 120 mm. and 160 mm. and the maximum length ranges between 185 mm. and 225 mm. Weight of fingerlings three months olds, ranges between 12 grams and 18 grams. Minimum sized six months old weigh between 18 grams and 65 grams, while maximum sized ones weigh between 65 grams and 120 grams. Sizes at the eighth month range between 186 mm. and 240 mm. and weigh between 115 grams and 140 grams. The maximum length and weight is attained by about the tenth month the same being 254 mm. and 190 grams for females and 297 mm. and 180 grams for males.

Mortality is negligible till the sixth month but gradually increases after that and is about 75 per cent by the tenth month. They continue to live in small numbers and are lost totally by the end of one year and three months, only ten per cent being available at the end of one year.

Growth studies in 1963-64 reveal that although growth on the whole is comparatively poorer during that year, it is in principle the same. The fingerling stage is reached by the fourth month and average sizes of 120 mm. to 190 mm. with a weight range of 20 grams to 75 grams are reached by the sixth month. Maximum length and weight is reached about the tenth month this being 214 mm. and 97 grams in September 1963. The bar opened in October 1963 and again by the fourth month sizes of 142 mm. with weights of 20 grams were recorded.

3. *Metapenaeus monoceros.*—Growth of the few specimens available in 1963 showed the following sizes :—

	Length range in mm.	*Weight range in grams.*
(1)	(2)	(3)
May 1963	49—65	0·5—1
June 1963	65—75	1·5—5
July 1963	63—78	1·5—5
August 1963	65—86	2·5—6·5

Growth is extremely poor and the maximum attained four months after entry of the larvae is only a length of 86 mm. with a weight of 6·5 grams. Individuals are found to disappear four months after the closing of the bar in May 1963. A single stray large specimen 112 mm. in length and 10 grams in weight has been recorded in September 1960 and another 114 mm. long and 11 grams in weight in February 1964.

4. *Metapenaeus dobsoni.*—Growth was observed in 1963-64, as appreciable numbers were found to enter during the year. The maximum length was reached by the third month. and was about 86 mm. and 5·0 grams after which there was a general disappearance. Average length and weight in the third month ranges between 7·7 and 8·6 mm. and 2·5 and 5·0 grams.

5. *Harvesting.*—This is best done in the fourth month in the case of *Penaeus indicus* as after this mortality rate increases. Prawn larvae are continuously appearing from the time the bar opens to the time it close although the numbers that enter vary, there being spasms of abundance from time to time. Annual harvesting will not be feasible as those that enter early will die out after the fourth month and those that enter when the bar closes will remain only till August, the latest. Three to four harvests can be made per annum to avoid losses by mortality, the longest that they can be kept being four months. A still better method will be to use cast nets of three-fourth inch mesh and over and to harvest out the average sized prawns every month from the fourth month since their first entry after the opening of the bar and onwards.

Penaeus carinatus is best harvested in the sixth month and in this case one inch to one and a quarter inch mesh cast nets may be used to harvest out the large sized Penaeus carinatus every month from the sixth month of its entry into the estuary.

Metapenaeus monoceros can be harvested every fourth month whereas *Metapenaeus dobsoni* will have to be collected and disposed even in the third month.

7. *Production.*—Production of a combination culture of all four species of prawns with one harvest during the year works out to 125 kilo per acre per annum at a stocking rate of 12,500 per acre. This can be more than doubled if the rate of stocking is doubled and harvesting is done every fourth month, if not every month after the first four months. Average harvesting sizes are 140 mm. length and 25 grams weight for *Penaeus indicus,* 200 mm. length and 75 grams for *Penaeus carinatus* 80 mm. and 4 grams for *Metapenaeus dobsoni* and 130 mm. and 25 grams for *Metapenaeus monoceros.*

The estuarine production during the years 1963-64, 1964-65 and 1965-66 are shown in Tables 49 and 50 giving the month war details. The prawn fishery dwindles three months after the closing of the bar in all three years and is even nil, in years when sufficient larvae do not enter, from the fifth month onwards till the bar opens and larvae again enter. In May 1965 prawns were totally absent, reappearing in July 1965 after unfair weather conditions had been tided over, the individuals probably hibernating in the bottom as was usually observed in Aquarium and experimental pond conditions. Annual production is seen to vary from 33,155 kilograms in 1963-64, to 14,533 kilograms in 1964-65 and only 2,507·5 kilograms in 1965-66, which happens to be a particularly bad year as the entry of prawn larvae was unusually poor. In 1963-64 prawn was the predominant fishery in the Adyar Estuary in the months of April, May, June and July 1963 and January, February and March 1964 and third in predominance in December 1964. In 1964-65 it was the predominant fishery in October and November 1964 and was third in predominance in the total fish landings for December 1964 and January and February 1965. In 1965-66 it was third in the order of predominance in June 1965 only. The period between May and September are usually lean months when due to closure of the bar and scarcity of prawn larvae production declined. Prawns have been recorded throughout this period only when the bar remains open till May as in 1963 and opens as early as August as in 1961 and 1962.

8. *Acclimatisation and culture.*—Natural stocking is found preferable in the case of *Penaeus indicus* unless it is done in the early post-larval stage. However *Penaeus carinatus*, a large growing species but occurring in small numbers has to be segregated in the fingerling stage of 90 mm. to 110 mm. and transplanted if it is desired to culture them on a large scale. They are found to be more hardy and can stand transport well even in the fingerling stage in oxygen tin carrier or in double walled plastic bags half filled with water and with two to three individuals per bag. Experiments show that they are easily acclimatised to fresh water in which they thrive splendidly growing to equally large sizes. They can be cultured in inland freshwater ponds if proper steps are taken to transport them effectively.

Prawn culture can be profitably combined with Chanos and Mullet culture without detriment to each other. *Elops indicus* is extremely harmful to prawn culture as every individual, big or small collected from a prawn pond was found with a *Penaeus indicus* down its gullet. Other predators such as *Therapon jarbua*. *Serranus* species and *Megalops cyprinoides* have also to be weeded out. Tilapia competes with the food and space of prawns and is undesirable in prawn culture. The backwater jelly fish, *Acromitus flagellatus* increase rapidly in numbers in brackishwater ponds and are also a menace to the very existence of prawns which die out when there is an abundance of these jelly fish, every haul of the cast net or bag net being jelly fish and jelly fish alone. Removal of jelly fish even in the early stages with the help of velon screen hand nets is an important item of work to be attended to in prawn culture.

9. *Maturity and breeding.*—Mature prawns in breeding stages have not been recorded either in the ponds or the estuary. It is however possible to differentiate them into males, females and undifferentiated individuals. It is not possible to differentiate the sex in *Penaeus indicus* and *Metapenaeus monoceros* up to a length of 65 mm. Sex can be differentiated at a length of 105 mm. in *Penaeus carinatus* and at a length of 50 mm. in *Metapenaeus dobsoni*. The average maximum size of *Penaeus indicus* available in the estuary is about 145 mm. and 25 grams while that of *Penaeus carinatus* is 191 mm. and 64 grams. *Metapenaeus monoceros* 114 mm. length and 13 grams weight and *Metapenaeus dobsoni* of 92 mm. length and 4 grams weight are the maximum sizes available in the estuary. Availability of individuals over and above these size are rare. Females usually predominate over the males in numbers. They are usually longer than the males but the males are heavier. Prawns disappear after the average maximum size is reached. Breeding is quite evidently in the sea, as the larvae are absent in the plankton of the estuary, only post-larvae being very rarely present in the plankton but occurring abundantly as demersal forms. Attempts were made in 1964-65 to induce sex differentiated prawns to breed. Injection of *Penaeus indicus* of length range 125 mm. to 147 mm. and weight range 28 grams to 30 grams and *Penaeus carinatus* of length range 180 mm. to 240 mm. and weight range 50 grams to 75 grams with Androgenic and Oestrogenic extracts made from the Androgenic glands of male *Palaemon idae* and the ovaries of female *Palaemon idae* was tried. The injected specimens were reared in small nurseries. *Penaeus indicus* was of a pale white colour before the injections. After repeated injections once every fortnight, thrice the appendages were found to take on a reddish tinge but very little development was noticed in the gonads. These experiments were repeated several times with no further success and it was felt that mere hormonal treatment was insufficient to induce gonadal development and spawning, a conducive tidal environment also being necessary, this being absent in the nurseries at the time of the experiments.

Discussion.

Observations made on the occurrence of prawns in the Adyar estuary are interesting and noteworthy. The absence of post-larvae after the closure of the bar and their appearance only after the opening of the same makes it clear that breeding does not take place in the estuary for any of the four species under study. Adults disappear from the estuary after reaching an average maximum size and there is every possibility that their homing instinct urges them back to their natural breeding grounds far out into the sea where environmental conditions are adequate and conducive to enable development of gonads and spawning. Although a higher maximum growth is reached in the culture ponds they die out after this stage, as an escape back into the sea is impossible. Panikkar and Menon (1955) correlate this natural and instinctive migration with their homoiosmotic behaviour. While the migration of the larvae is passive as they are wafted into the estuary by favourable winds and currents, the seaward migration is a more active one with a definite goal ahead.

Estuaries undoubtedly play a remarkable role in the development and perpetuation of shrimp resources. However one is dependent on the sea for the stock of post-larvae which enter and which vary from year to year. The bar plays the post of an intermediary and should be open to facilitate entry of the post-larvae. Menon and Raman (1961) have observed prawn catch to be low in dry years and high in wet years there being a definite relationship between catch and rainfall. According to them the first few showers of the South-West monsoon usually falling in May stimulate an active seaward movement resulting in a sharp rise in the prawn catch. George (1962) has found a possible relationship of seasonal fluctuations in recruitment of post-larvae with changes in the salinity of the water. He states that Metapenaeus dobsoni is abundant in the months of low salinity while peak recruitment of *Penaeus indicus* is in the months of high salinity. Subrahmanyam (1966) correlates the relative abundance of prawns with the monthly river discharges. George (1962) has also stated that the behaviour of prawn directly or indirectly plays an important part in influencing the catch. George (1961) in his observations on the prawn landings of Cochin and Allepey coast has also found that maximum prawn landings were recorded when the dissolved oxygen contents and temperature were low and salinity and pH were high while landings were poor when dissolved oxygen contents were high.

At Adyar recruitment of larvae have definitely been better in the wet years when the freshwater flood discharge from the river during the North-East monsoon has been heavy. The larvae however do not enter when the salinity is extremely low but appear only after tidal ingress and egress is established. In 1963 larvae started appearing four days after the opening of the bar whereas in 1964 it was twelve days after and in 1965 nearly a month after. Tables 22 to 29 show that temperature and salinity are low when the flood waters force open the bar while there is an increase in salinity as tidal influence is felt up the estuary. The dissolved oxygen contents also which is high just before the opening the bar also gradually lowers.

Metapenaeus dobsoni is abundant about December to January whereas *Penaeus indicus* larvae are abundant even from August provided the bar opens and is the major fishery throughout provided the bar remains open at least till May. How far the appearance of *Metapenaeus dobsoni* can be correlated with salinity is not known although salinity is slightly lower than what it was just before its appearance in abundance (*vide* Tables 25 and 26).

Regarding the behaviour of prawns the burying of prawns during adverse conditions particularly drought has been observed in the aquaria, the ponds and in the estuary, and this certainly affects the prawn catch. Prawn catch was poor in April 1965 and nil in May 1965 but reappeared in considerable number in June even though the bar was closed after a few stimulating showers which awakened them from their hibernation. Similar observations were made in August 1963 when prawns were absent during the beginning of the month but suddenly appeared even though the bar was closed after heavy rain. This reappearance even though the bar is closed has led to a misapprehension that the prawns are breeding in the estuary. The sizes so recorded have never been less than 80 mm. making it clear that the phenomenon is one of hibernation and reappearance rather than an indication of breeding in the estuary, especially when the bar is closed and drought conditions prevail.

George (1962) records a year round breeding for *Metapenaeus monoceros* and *Metapenaeus dobsoni* with two peaks, one from June through August and the other in November, December the monsoon months but Menon (1955) records a prolonged breeding from May to December. For *Penaeus indicus*, George (1962) has recorded a spawning period from October to May with two peaks one in the hot months February through April and the other in November, December.

In the Adyar estuary the bar closes the latest in May and opens the earliest in August. Two peak periods of occurrence of *Penaeus indicus* is noticed one in November, December and the other in March, April although larvae are continuously available from August or whenever the bar opens. One peak in January, February is noticed for *Metapenaeus dobsoni* and as the bar closes by May there is no chance of observing the other peak. The peak for *Metapenaeus monoceros* is November, December and March, April as is for *Penaeus indicus* and *Penaeus carinatus*. *Metapenaeus monoceros*, *Metapenaeus dobsoni* and *Penaeus carinatus* are not available continuously as is Penaeus indicus.

Menon (1955) and Panikkar and Menon (1955) have observed *Metapenaeus dobsoni* in the backwaters, mature size ranging from 70 mm. to 80 mm. Menon (1955) has recorded males at 67 mm. sizes with completely developed petasma and spermatozoa inside the vasdeferens though spermatophores had not yet developed. In the Adyar estuary and brackish-water ponds, male specimens 65 mm. in length and over were found with well developed petasma while impregnated females of this size were also recorded although it was not known whether breeding was actually taking place in the estuary itself.

Differential growth rate in sexes of *Metapenaeus dobsoni* has been recorded by Menon (1955) growth being higher in females. Rajyalakshmi (1961) has noted a similar faster rate of growth in *Metapenaeus brevicornis*. George 1961 has also recorded this. The study of the rate of growth of male and female *Penaeus indicus* and *Penaeus carinatus* in the estuarine farm ponds at Adyar give the same results (*vide* graphs 1 to 8).

Menon (1957) studied in the sex ratio of *Metapenaeus dobsoni* and found that females preponderate in the earlier stages while in the later groups males and females are equal in number. Rajyalakshmi (1961) has also found the females to predominate in the case of *Metapenaeus brevicornis*. Females are found to predominate in *Penaeus indicus* at all stages in the Adyar estuary from the time sexes are differentiated to the time when they migrate back to the sea.

The duration of life spent by prawns in the Adyar estuary is very short and the opening and closing of the bar is partly responsible for this. The largest size recorded for *Penaeus indicus* in the estuary is 146 mm. and 42·5 grams though in the ponds it attains a length of 189 mm. and 90 grams. This is attained in about six months time after which they perish if they are in the ponds or migrate back to the sea where conditions are conducive if they are not fished out.

Penaeus carinatus attains a length of 225 mm. and a weight of 64 grams in the estuary in about a year. In the ponds it attains a maximum length of 297 mm. and 190 grams in ten months. There is possibility that the *Penaeus carinatus* migrate back to sea when they are about ten months or 12 months old if they are allowed. *Metapenaeus monoceros attains* a maximum size of 114 mm. and 13·5 grams in the ponds in the space of six months though the normal growth in four months is about 86 mm. and 6·5 grams. The large sizes probably migrate in the fourth month into the sea if possible. *Metapenaeus dobsoni* attains a maximum length of 92 mm. and 4·5 grams in three months in the estuary while its growth in the ponds is only about 86 mm. and 5 grams in the same period. They disappear after this in the ponds and probably migrate at this stage into the sea if the bar is open. Menon (1955) has recorded a size of 100 mm. in the backwater for *Metapenaeus dobsoni* largest size of females being 124 mm. and males 111 mm. while George (1959) has recorded a maximum size of 170 mm. to 180 mm. for *Metapenaeus monoceros*. These sizes are not attained either in the Adyar estuary or farm ponds. Menon and Raman (1961) have recorded the biggest group of *Penaeus indicus* available as 130 mm. to 140 mm. and indicate that they pass out into the sea by about 110 mm. when they are about one year old. Growth in the Adyar river and ponds is far more rapid especially in the first four months and size of 140 mm. is easily attained in the first six months in the estuary and in the first four months in the ponds. Tabulations will show that the common sizes landed range between 70 mm. and 114 mm. and we can agree with Menon (1957) in saying that the vast majority captured from the backwaters do not excee 120 mm. in length. He has recorded maturity at a size of 150 mm.

Menon (1954) in an experiment conducted a Narakkal has shown that a minimum o 800 lb. of prawns could be harvested annually from every acre. In the Adyar estuarine pond 125 kilograms has been easily harvested pe acre at a stocking rate of 12,500 once a year Mortality rate has been as high as 75 per cen as a result of keeping the prawns overlong This can easily be enhanced four times if no more provided harvesting is done every fourt month continuously at a stocking rate of 30,00 fry per acre or harvesting is done every mont from the fourth month in ponds that ar stocked naturally using three-fourth inch mes castnets for fishing so that the four-months old only are landed every month. Mortality rat will not exceed 50 per cent and can be expecte to be 25 per cent due to natural cause Expected yield will then be not less tha 500 kilograms if not more and will compar favourably with the yield in the tambaks East Java which range between 230 lb. an 830 lb. per acre as recorded by Schuster (195 and that in the Sugpo ponds of the Phillippine as given by Villadolid and Villaluz (195 which is as much as 315 lb. per acre pe annum.

Manuring with cowdung will help in increasing prawn production in that more food will be provided by an increase in phytoplanktonic and algal out put and in the formation of a more alluvial bottom where polychaetes will thrive. It would particularly be useful in the culture of the largest growing species *Penaeus carinatus* five of which would contribute to a pound if properly fed and grown.

In conclusion it may be said that the future of the prawn fishery in Madras State is encouraging in that there is much scope for the development of marine prawn culture in brackishwater farms. A survey of all the low lying brackishwater areas in the six coastal districts of the Madras State has been taken up and it is expected to establish a number of shrimp farms along the coast for the production of commercially important shrimp as is done in the coastal shrimp farms of Thailand. Prawn pond operation has still to be perfected for satisfying results and advanced cultural techniques as is perfected in Japan and at the Galvestone Biological Laboratory, Texas, for the rearing of shrimp larvae will have to be resorted to and developed, where it is not possible to keep the bar open at least for nine months in the year to ensure sufficient stock of prawn larvae for the working of these farms continuously throughout the year.

Acknowledgement.

Thanks are due to Thiru A. J. Thangadurai, B.Sc. and Selvi C. Durga, B.Sc., who were responsible for analysing the water and soil samples under study.

References

1. Central Inland Fisheries Institute (1962)—Information on prawns from Indian waters. Synopsis of Biological data, Proc, Indo. Pacific Fish Counc. 11, pp. 123-133.

2. Chacko, P. I. (1955)—Prawn fisheries of Madras State (India). Contribution from the Marine Biological Station, West Hill, Malabar Coast No. 3, Government Press; pp. 1-14.

3. Chopra, B. N. (1939)—Some food prawns and crabs of India and their fisheries—Journ. Bom. Nat. Hist. Soc., 41(2), pp. 221-234. ..

4. Chopra, B. N. (1943)—Prawn fisheries of India. Presidential address, Indian Science Congr. Proc. Pt. 11, pp. 153-173.

5. George, M. J. (1959)—Notes on the Bionomics of the prawn Metapenaeus monoceros Fabricius. Indian J. Fish., 6 (2), pp. 268-279.

6. George, M. J. (1961)—Studies on the prawn fishery of Cochin and Allepey coast. Ind. Journ. of Fish. VIII (1), pp. 75-95.

7. George, M. J. (1962)—On the breeding of Penaeids and the recruitment of their post larvae into the Backwaters of Cochin. Ind. Journ. of Fish IX(1), pp. 110-116.

8. Gopalakrishnan, V. (1952)—Food and feeding habits of *Penaeus indicus* M.Ed., J. Madras Unv. B. 22 (1), pp. 69-75.

9. Gopalakrishnan, V. (1957)—Studies on the biology of Penaeids. Madras Unv. Publication 111.

10. Gopinath, P. (1955)—Prawn culture in the rice fields of Travancore-Cochin, India. Proc. Indo-Pacific Fish Counc. 6·3, pp. 419-424. 424.

11. Kubo, I. (1955)—A review of the biology and systematics of shrimps and prawns of Japan. Proc. Indo-Pacific Fish Counc. 6 (2 and 3), pp. 387-393.

12. Kutkuhn, H. Joseph (1964)—The role of estuaries in the development and perpetuation of commercial shrimp resources. American Fisheries Society Special Publication No. 3, pp. 16-36.

13. Menon, M. K. (1951)—The life history and bionomics of an Indian Penaeid prawn *Metapenaeus dobsoni* Miers. Proc. Indo-Pacific Fish Council 3(2-3), pp 80-93.

14. Menon, M. K. (1953)—Notes on the bionomics and fishery of the prawn *Parapeneopsis stylifera* (M.Edw.) on the Malabar Coast. J. Zool., Soc., India 5 (1), pp. 153-162.

15. Menon, M. K. (1955)—Notes on the bionomics and fishery of the prawn *Metapenaeus dobsoni* Miers on South West Coast of India. Indian J. Fish 2(1), pp. 41-56.

16. Menon, M. K. (1955)—Identification of Marine Inshore Prawns of commercial value in India. Proc. Indo-Pacific Fish Council 6(3), pp. 345-347.

17. Menon, M. K. (1955)—Observations on the paddy field prawn fishery of Travancore-Cochin together with an account of an experiment in prawn culture. Proc. Indo-Pacific Fish Council 5.

18. Menon, M. K. (1957)—Contributions to the biology of Penaeid prawns of the South West Coast of India 1. Sex ratio and movements. Ind. Journ. of Fish 4 (1), pp. 62-74.

19. Menon, M. K. (1958)—Prawn Fisheries; Fisheries of the West Coast of India—Edited by Dr. S. Jones, pp. 45-54.

20. Menon, M. K. and Raman, K. (1961)—Observations on the prawn fishery of the Cochin Backwaters with special reference to the Stake net catches. Ind. Journ. of Fisheries VIII (1), pp. 1—23.

21. Panikkar, N. K. and M. K. Menon (1955)—Prawn fisheries of India—Proc. Indo-Pacific Fish Counc. 6 (3), pp. 328-344.

22. Panikkar, N. K. (1937)—The prawn industry of the Malabar Coast. Journ. Bombay Nat. Hist. Soc. 39, pp. 343—553.

23. Racek, A. A. (1956)—Penaeid prawn fisheries of Australia with special reference to New South Wales. Proc. Indo-Pacific Fish Counc. 6 (3), pp. 347—351.

24. Rai, H. S. (1933)—Shell fisheries of the Bombay Presidency, J. Bombay Nat. Hist. Soc., 36.

25. Rajyalakshmi, T. (1961)—Observations on the biology and fishery of *Metapenaeus brevicornis* (M. Edw. in the Hooghly Estuarine System. Ind. J. of Fish VIII (2), pp. 383—402.

26. Rajyalakshmi, T. (1964)—On the age and growth of some estuarine prawns. Proc. Indo-Pac. Fish Coun. 11 (2).

27. Shaik Mahmud, F. S. (1960)—Study of Bombay Prawns. The seasonal fluctuation and variation in abundance of the commercially important species of Bombay prawns with a brief note on their size, state of maturity and sex ratio. Ind. J. Fish. 7 (1), pp. 69-81.

28. Srivatsa, K. R. (1953)—A survey and comparative analysis of the prawn (shrimp) fishery of the Gulf of Kutch in Saurastra in Western India, Government of Saurashtra Publications.

29. Subrahmanyam, C. B. (1965)—On the unusual occurrence of penaeid eggs in the inshore waters of Madras Joun. of the Marine Biol. Assoc. of India VII (1), pp. 83—88.

30. Subrahmanyam, M. (1964)—Fluctuations in prawn landings in the Godavari estuarine system. Proc. Indo. Pacific Fish. Coun. If, Spl. Pub. No. 1.

31. Schuster, W. H. (1952)—Fish culture in Brackish water ponds. Indo-Pacific Fish. Coun. Spl. Pub. No. 1.

32. Villadolid. D. V. and D. K. Villaluz (1950)—The cultivation of Sugpo, *Penaeus monodon* Fabricus in the Phillippines, Proc. Indo. Pacific Fish Coun. 2, pp. 11—111.

33. Zylva, E. R. A. de (1955)—The prawn Fisheries of Ceylon. Proc. Indo. Pacific Fish Counc. 6 (1).

TABLE 1.

Details of closing and opening of the Bar of the Adyar River.

Year (1)	*Date of closing.* (2)	*Date of opening.* (3)
1959	....	..
1960	....	2nd October 1960.
1961	29th May 1961	5th August 1961.
1962	15th March 1962	23rd August 1962.
1963	4th May 1963	21st October 1963.
1964	9th January 1964	5th September 1964.
	9th September 1964	16th September 1964.
	30th September 1964	1st November 1964.
1965	30th January 1965	17th November 1965.
1966	13th March 1966	15th March 1966.
	17th March 1966	1st May 1966.
	14th May 1966	29th August 1966.
	2nd September 1966	27th September 1966.

TABLE 2.

Meteorology for 1960–61.

Months.	*Air Temp.* *Maximum.* oC.	*Air Temp.* *Minimum.* oC.	*Relative Humidity. Percentage.*	*Water surface Temperature.* oC.	*Specific gravity.*
(1)	(2)	(3)	(4)	(5)	(6)
1960—					
April	31·0	28·25	..	31·0	1·001
May	35·5	31·5	..	30·5	1·001
June	34·25	31·0	..	29·25	1·001
July	31·25	29·0	..	31·0	1·001
August	33·25	29·25	..	30·0	1·010
September	30·0	27·25	74·5	30·0	1·015
October	29·75	27·25	66·5	29·75	1·021
November	26·25	23·75	82·06	26·5	1·005
December	26·75	23·75	83·0	27·5	1·001
1961—					
January	26·5	24·5	78·5	28·25	1·007
February	27·0	26·0	83·0	29·0	1·001
March	29·25	27·25	80·0	30·25	1·016

TABLE 3.

Meteorology for 1961–62.

Months.	*Air Temp.* *Maximum.* oC.	*Air Temp.* *Minimum.* oC.	*Relative Humidity. Percentage.*	*Water Surface Temperature.* oC.	*Specific gravity.*
(1)	(2)	(3)	(4)	(5)	(6)
1961—					
April	32·5	30·0	71	32·2	1·018
May	33·8	31·9	66	30·7	1·016
June	31·5	28·5	79	29·75	1·017
July	31·0	28·0	..	..	..
August	30·0	26·5	92	30·5	1·005
September	29·0	26·0	91	31·5	1·009
October	29·5	26·75	84·4	32·7	1·010
November	27·5	25·5	83·0	23·5	1·010
December	26·5	24·5	83·0	28·0	1·10
1962—					
January	24·5	23·5	83·0	26·5	1·012
February	27·0	26·0	83·0	28·5	1·016
March	29·76	27·3	83·0	30·85	1·018

TABLE 4.

Meteorology 1962–63.

Months. (1)	*Air Temp.* *Maximum.* oC. (2)	*Minimum.* oC. (3)	*Humidity Percentage.* (4)	*Water temperature* oC. (5)	*Specific gravity.* (6)
1962—					
April	32	29	86	32·0	1·020
May	31	29	85	31·0	1·013
June	32	29	65	31·0	1·005
July	32	26	65	31·0	1·004
August	32	27	86	30·0	1·005
September	31	28	62	31·0	1·005
October	29	28	88	28·0	1·008
November	28	25	87	27·0	1·008
December	26	24	97	27·0	1·013
1963—					
January	26	24	84	26·0	1·013
February	26·50	25·00	52	26·0	1·015
March	29	26	84	30·0	1·018

TABLE 5.

Mctorology for 1963–64.

Months. (1)	*Air Temp.* *Maximum.* oC. (2)	*Minimum.* oC. (3)	*Relative Humidity Percentage.* (4)	*Weather condition.* (5)	*Nature of bar opening.* (6)
1963—					
April	30	28	86	Showers for 3 days.	....
May	31	28	71	Bright sun	Bar closed on 4th May 1963.
June	31	30	94	Rain for 6 days	....
July	31·0	30·0	88	Rain for 20 days	....
August	30·0	28·0	88	Rain for 15 days	....
September	28·0	27·0	92	Rain for 6 days.	....
October	28·0	27·0	87	Rain for one day	BO 21st October 1963. BC 27th October 1963.
November	27·0	26·0	86	Rain for two days	BC 5th November 1963
December	25·0	24·0	91	....	....
1964—					
January	24·0	23·0	91	....	BC 9th January 1964
February	26·0	25·0	91	....	....
March	28·0	27·0	91	....	....

BO Bar opened on

BC Bar closed on.

TABLE 6.

Meteorology for 1964–65.

Months.	*Air Temp.*		*Relative Humidity. Percentage.*	*Weather condition.*	*Nature of Bar opening.*
	Maximum. oC.	*Minimum. oC.*			
(1)	(2)	(3)	(4)	(5)	(6)
1964—					
April	30·0	28·0	88	Bright sun	....
May	31·0	30·0	85	Bright sun	....
June	31·0	30·0	88	Hot sun.	....
July	29·0	28·0	92	....	....
August	28·0	27·0	92	....	....
September	29·0	26·0	77	Rain for 3 days	BO 5th September 1964, BC 9th September 1964.
October	29·0	28·0	81	Rain for 3 days	BO 16th September 1964, BC 30th September 1964.
November	26·0	24·0	78	Rain for 15 days	Bar opened on 1st November 1964.
December	25·0	24·0	82	Rain for 3 days	....
1965—					
January	26·0	24·0	74	....	BC 30th January 1965.
February	26·0	25·0	75	....	....
March	28·0	27·0	75	....	....

TABLE 7.

Meteorology for 1965–66.

Months	*Air Temp.*		*Humidity. Percentage.*	*Water temperature, oC.*	*Specific gravity.*
	Maximum. oC.	*Minimum. oC.*			
(1)	(2)	(3)	(4)	(5)	(6)
1965—					
April	29	28	72	29·0	1·027
May	32	30	64	30·0	1·030
June	32·5	30	56	29·5	1·025
July	29	28	57	26·0	1.024
August	27	26	76	22·0	1·019
September	29	26	60	23·0	1·022
October	28	27	80	22·0	1·021
November	27	25	79	21·0	1·019
December	28	25	82	20·0	1·008
1966—					
January	28	25	79	21·0	1·006
February	28	25	78	22·0	1·014
March	28	27	75	24·0	1·023

TABLE 8.

Hydrology for 1959–60.

In stock pond

Months. (1)	*Salinity %o.* (2)	*pH.* (3)	*Oxygen cc/L.* (4)	*Carbondi-oxide ppm* (5)	*Carbonates. ppm.* (6)	*Bicarbonates ppm.* (7)	*Silicatates. MG/L.* (8)	*Turbidity. Mm.* (9)
1959—								
September	28·01	8·4	4·06	Nil.	1·5	71·0	12·5	395·0
October	15·78	8·4	3·55	Nil.	6·0	116·0	26·0	405·0
November	9·93	8.5	5·512	Nil.	1·8	81·0	19·0	420·0
December	21·4	8·7	4·34	Nil.	2·7	119·0	45·4	410·0
1960—								
January	21·7	8·7	4·2	Nil.	2·0	112·0	46·0	327·0
February	31·5	8·7	4·21	Nil.	5·0	119·0	49·3	310·0
March	31·0	8·7	4·5	Nil.	3·0	121·65	73·5	297·5

TABLE 9.

Hydrology for 1960–61.

In stock pond S1.

Months. (1)	*Temp. oC.* (2)	*Sp. Gr.* (3)	*Turbidity. mm.* (4)	*Salinity %o.* (5)	*Oxygen cc/L.* (6)	*Carbon dioxide ppm.* (7)	*Silicate Mgm/L,* (8)	*pH.* (9)	*Depth.* FT. (10)	INCHES.
1960—										
April	27·00	1·020	45·6	36·6	5·75	Nil.	52·1	8·4	4	8
May	27·5	1·020	41·0	35·6	4·34	..	50·0	8·4	4	6
June	26·0	1·020	41·5	36·1	4·27	..	63·3	8·4	4	10
July	27·5	1·020	45·0	36·2	4·34	2·0	62·5	8·4	5	2
August	28·0	1·020	54·5	36·0	4·50	..	69·0	7·4	5	6
September	28·5	1·021	71·0	31·06	4·06	..	62·0	8·0	6	0
October	27·5	1·012	56·0	21·25	4·69	2·0	31·25	7·8	6	0
November	26·0	1·010	80·0	10·15	4·41	2·0	11·25	7·6	6	3
December	26·0	1·001	100·0	20·6	4·06	1·0	11·30	7·8	3	6
1961—										
January	26·5	1·010	130·0	22·78	4·20	1·1	10·0	7·8	5	0
February	27·0	1·012	109·0	25·82	4·06	1·0	22·0	7·6	4	6
March	27·5	1·012	120·0	30·57	5·62	..	32·12	8·0	4	3

TABLE 10.

Hydrology for 1961–62.

In stock pond S1.

Months. (1)	*Salinity %o.* (2)	*Oxygen. cc/L.* (3)	pH. (4)	*Carbon-dioxide ppm.* (5)	*Carbonate ppm.* (6)	*Bicarbonate ppm.* (7)	*Silicate. mgm/L.* (8)	*Phosphate ppm.* (9)	*Temp. oC.* (10)	*Turbidity.* (11)	*Sp. Gr.* (12)
1961—											
Apri	35·15	3·25	8·4	..	3·5	32·0	48·0	1·39	28·5	75·5	1·020
May	31·60	3·16	8·0	..	1·8	39·65	36·0	0·58	30·5	84·0	1·020
June	27·75	4·06	8·01	..	1·5	20·13	24·25	0·72	29·05	72·5	1·020
July	16·75	4·20	8.2	..	1·6	32 50	17·5	..	28·0	85·0	1·012
August	20·30	4·36	8·6	2·5	..	28·0	7·5	..	23·5	91·5	1·010
September	19·90	3·98	8·4	1·8	..	29·0	7·8	0·72	31·5	75·5	1·010
October	17·75	4·55	7·8	2·0	..	36·5	6·75	..	31·5	80·5	1·010
November	16·66	4·60	7·8	1·5	..	43·01	8·5	0·68	28·0	80·0	1·010
December	17·25	4·13	8·2	1·2	..	41·5	8·0	..	27·5	85·5	1·010
1962—											
January	10·08	4·13	8·2	..	1·5	36·60	10·0	1·40	28·0	87·0	1·012
February	24·09	3·99	8·0	2·0	..	43·31	12·5	..	28·5	94·5	1·016
March	26·90	4·06	8·0	1·3	..	45·75	13·5	1·42	30·0	94·0	1·020

TABLE 11.

Hydrology for 1962—63.

Pond I.

Months.	*Temp. oC.*	*Specific gravity.*	*Transparency cms.*	*pH.*	*Salinity o/oo.*	*Oxygen cc/L.*	*Carbondioxide ppm.*	*Carbonate ppm.*	*Bicarbonate ppm.*	*Silicate Mgm/L.*	*Phosphat ppm.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
—											
April	32·5	1020	98·0	8·0	29·14	4·0	2·0	..	50·74	15·50	0·81
May	32·5	1·018	96·0	8·1	26·70	4·20	1·0	..	46·36	13·00	1·00
June	31·0	1·005	63·0	8·3	16·50	3·85	1·0	..	46·36	13·00	1·00
July	31·5	1·005	59·0	8·0	17·325	4·27	2·0	..	50·325	10·50	0·80
August	31·0	1·005	54·0	7·8	18·67	3·99	1·0	..	50·325	12·50	0·90
September	29·0	1·007	54·5	7·8	18·23	3·78	1·5	..	51·85	12·50	0·72
October	28·5	1·000	61·5	8·0	20·26	3·50	2·0	..	51·85	11·50	0·70
November	27·0	1·010	73·0	8·0	20·86	4·23	..	1·5	50·325	10·50	0·72
December	26·0	1·012	73·5	8·0	21·90	4·06	2·0	..	48·50	12·0	0·72
1963—											
January	26·00	1·015	91·0	8·2	20·96	4·06	1·5	..	49·41	14·00	1·00
February	27·5	1·015	79·9	7·8	24·68	4·13	3·0	..	51·85	17·50	1·20
March	28·5	1·017	88·0	8·0	27·98	4·34	2·2	..	52·40	20·25	1·80

TABLE 12.

Hydrology for 1963–64 in stock pond (S1).

	April.	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Salinity o/oo	28·20 o/o	27·99	..	27·01 o/o	22·92	22·52	28·68	17·65	17·17	20·58	21·51	18·25
2 Oxygen cc/L	4·17	4·34	..	4·24	4·31	4·10	3·54	2·41	3·46	3·12	3·70	4·2
3 pH	8·1	8·2	..	7·7	7·6	7·8	7·8	7·9	7·6	7·8	7·8	7·6
4 Carbondioxide ppm.	..	2·8	..	1·5	1·54	2·5	2·0	2·0	2·0	3·0	1·6	2·0
5 Carbonate ppm.	1·5	..	..	..	..	..	..	..	..	..	..	..
6 Bicarbonate ppm..	51·85	50·02	..	45·53	40·4	38·07	36·09	32·025	41·18	39·65	41·18	54·9
7 Silicate Mg/L	23·25	28·17	..	14·57	17·03	16·67	16·67	10·0	17·00	13·67	14·0	15·0
8 Phosphate ppm.	1·70	1·20	..	0·25	0·8457	..	0·5184	0·4099	0·428	0·4253	0·3861	0·4139
9 Temperature oC	29·5 oC.	31·00	..	26·0 oC.	27·7 oC.	27·0 oC.	27·0 oC.	25·50 oC.	26·0 oC.	26·0 oC.	26·5	27·0
10 Sp. Gravity	1·020	1·020	..	1·010	1·005	1·005	1·008	1·005	1·014	1·023	1·023	1·023
11 Turbidity	76·054	48·6cm.	..	56·0 cm.	60·5 cm.	64·0 cm.	66·0	55·5	55·5	50·5	51·5	48·5
12 Depth	3′8″	40″	..	4′9″	5′4″	5′4″	5′6″	4′7½″	4′9″	4′2″	4′3½″	4·0″

TABLE 13.

Hydrology for 1964–65 for stock pond (S1).

	April 1964.	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Salinity o/oo	20·35	24	12·11	13·81	13·827	10·854	17·21	10·620	8·663	12·788	14·91	17·85
Oxygen cc/L	3·1	2·75	3·0	4·0	4·2	3·3	2·8	3·7	3·64	2·28	3·5	2·93
pH	8·2	7·9	8·2	8·3	8·2	8·1	8·1	8·2	8·0	7·9	7·8	8·1
Carbondioxide ppm.	2·0	2·0	..	..	..	..	..	..	..	..	4·0	..
Carbonate ppm.	..	..	3·0	3·5	2·66	..	2·0	3·0	2·0	2·5	..	3·5
Bicorbonate ppm.	41·18	28·98	47·28	50·33	44·72	50·325	56·18	44·23	36·60	41·18	57·95	51·85
Silicate Mgm/1	11·0	10·0	15·0	15·0	20·0	17·5	20·0	9·0	12·5	17·5	17·5	10·0
Phosphate ppm.	0·4068	0·3836	0·3652	0·3402	0·3403	0·3438	0·4616	0·3562	0·3126	0·2356	0·235	..
Temperature oC.	29·5oC.	31·0	29·5	26·5	24·4	24·0	25·0	23·0	23·5	25·5	27·5	27·5
Turbidity cm.	53·5	54·5	55·0	56·5	61·0	56·5	52·0	46·5	45·5	46·6	46·0	50·0
Depth	4′5½″	4′ 6½″	4′ 7″	4′ 8½″	5′ 3½″	4′ 8½″	4′ 8½″	3′ 9½″	3′ 7½″	3′ 9½″	3′ 9″	42¼″
Specific gravity	1·025	1·027	1·028	1·026	1·024	1·024	1·025	1·021	1·024	1·019	1·018	1·025

Table 14.

Stock Pond No. 2 (S1).

1965–1966.

(1)	*April* 1965. (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January* 1966. (11)	*February.* (12)	*March.* (13)
Salinity *o/oo*	17·10	16·24	15·42	10·85	12·01	8·6 o/oo	8·25	7·721	..	..	..	..
Oxygen *cc/L*	2·30	1·02	2·45	3·92	3·64	2·24	2·2	0·77	..	..	..	..
pH.	7·9	8·1	8·0	8·0	7·9	8·1	8·4	8·3	..	..	..	..
Carbondioxide *ppm.*	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	..	..	..
Carbonate *ppm.*	3·5	3·0	2·5	5·0	5·0	3·0	4·0	7·5	..	..	..	..
Bicarbonate *ppm.*	53·27	57·95	48·8	57·95	48·8	48·8	51·85	54·9	..	..	..	..
Silicate *Mgm/L.*	10·0	12·0	10·0	12·0	8·5	9·0	10·0	10·75	..	..	..	..
Phosphate *ppm.*	0·325	0·35	0·27	0·35	0·3	3·7	..	..	..	..	..	..
Temperature *oC.*	28·25	30·5	30·0	26·0	20·0	19·0	20·0	21·0	..	..	..	..
Specific gravity	1·017	1·030	1·029	1·026	1·118	1·018	1·018	1·020	..	..	..	..
Turbidity *cm.*	31·0	24·0	28·5	22·0	19·0	19·0	20·0	27·5	..	..	..	..
Depth	6′ 0″	5′ 3″	5′ 0″	5′ 0″	6′	5′ 8″	5′ 8″	5′ 5″	..	..	..	..

Table 15.

Hydrology for 1959–1960.

In the Adyar Reservoir (S9).

Months. (1)	*Temperature oC.* (2)	*Specific gravity.* (3)	*pH.* (4)	*Salinity o/oo.* (5)	*Oxygen cc/L.* (6)	*Carbondioxide ppm.* (7)	*Carbonates ppm.* (8)	*Bicarbonates ppm.* (9)
1959—								
November	25·0	1·001	8·4	15·0	3·55	Nil.	1·5	29·89
December	24·5	1·001	8·3	15·08	4·547	Nil.	2·4	26·84
1960—								
January	25·0	1·010	8·6	21·25	4·36	Nil.	3·3	25·01
February	24·0	1·010	8·7	18·15	4·06	Nil.	3·0	19·21

TABLE 16.

Hydrology for 1960–1961

Adyar Reservoir (S9).

Months. (1)	*Temperature oC.* (2)	*Sp. Gravity.* (3)	*Turbidity cms.* (4)	*pH.* (5)	*Salinity o/oo.* (6)	*Oxygen cc/L.* (7)	*Carbondioxide ppm.* (8)	*Carbonate ppm.* (9)	*Bicarbonate ppm.* (10)	*Silicate Mgm/L.* (11)
1960—										
September	28·5	1·020	86·0	7·4	30·10	4·34	Nil.	..	..	35·71
	29·0	1·020	52·0	7·4	14·10	4·27	Nil.	..	..	33·3
October	27·0	1·021	64·5	8·2	24·8	4·13	1·0	..	..	11·50
	27·0	1·020	57·5	7·6	8·10	4·27	2·0	..	..	10·0
November	26·5	1·010	62·0	7·4	8·32	4·05	2·0	..	..	8·0
	26·5	1·001	25·0	8·0	2·97	5·81	Nil.	..	..	11·25
December	27·0	1·001	74·0	8·4	1·713	4·06	Nil.	..	..	9·0
	25·0	1·001	29·5	8·2	22·58	4·27	1·0	..	..	7·5
1961—										
January	27·0	1·001	38·0	8·2	26·5	3·99	2·0	..	..	8·0
	26·0	1·010	35·5	9·6	24·58	4·55	Nil.	..	..	8·5
February	27·0	1·010	40·5	8·6	26·39	4·00	1·0	..	..	8·5
	27·0	1·012	43·0	8·4	28·72	3·01	..	3·0	15·25	22·5
March	28·0	1·012	28·0	8·2	27·02	5·60	..	8·0	24·4	62·5
	28·5	1·012	19·5	8·6	25·43	3·50	..	7·0	26·5	50·0

TABLE 17.

Hydrology for 1961–62.

Adyar Reservoir (S 9).

Months. (1)	*Temperature oC.* (2)	*Specific gravity.* (3)	*Turbidity cm.* (4)	*pH.* (5)	*Depth.* (6)	*Salinity O/oo.* (7)	*Carbondioxide ppm.* (8)	*Carbonate ppm.* (9)	*Bicarbonate ppm.* (10)	*Oxygen cc/L.* (11)	*Silicate Mgm/L.* (12)
1961—											
April	29·0	1·020	43	8·6	1′ 6″	33·96	..	3·0	25·25	3·7	53·8
May	31·5	1·018	37·8	8·4	11′ 2″	3·003	..	1·0	5·80	5·0	30·12
June	29·5	1·010	59·5	8·0	2′ 9″	15·425	..	1·8	12·0	4·925	24·0
July	28·0	1·004	42·5	8·4	2′ 9″	3·10	..	1·6	31·75	3·71	17·5
August	28·0	1·006	33·75	8·4	2′ 3″	10·15	..	2·0	27·75	3·81	0·75
September ..	29·0	1·010	48·5	8·2	1′ 9″	11·50	..	1·6	33·25	4·575	7·75
October	31·2	1·010	37·5	8·0	1′ 1″	8·70	..	2·2	32·30	6·75	7·25
November ..	29·0	1·010	34·0	7·8	1′ 4″	11·33	..	1·8	42·3	6·73	7·50
December	28·0	1·010	36·5	8·2	1′ 8″	18·33	..	1·8	42·0	5·83	7·50
1962—											
January	27·0	1·000	36·5	8·4	1′ 5″	22·2	..	1·8	44·83	4·76	10·0
Febru ry	28·5	1·016	45·5	8·6	1′ 9″	27·74	..	1·8	43·0	5·06	13·01
March	30·5	1·020	37·0	3·6	1′ 1″	29·6	..	1·5	46·59	5·06	15·0

TABLE No. 18.

Hydrology for 1962–63.

Reservoir Zone "B".

Months.	*Temperature. oC.*	*Specific gravity.*	*Turbidity mm.*	*Depth.*	*pH.*	*Salinity. %o*	*Oxygen. cc/L.*	*Carbon-dioxide ppm.*	*Carbonate ppm.*	*Bicarbonate ppm.*	*Silicate Mgm/L.*	*Phosphate ppm.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1962—												
April	33·0cc	1·020	28·5cm.	1' 9"	8·6	19·880	5·60	..	2·4	54·90	13·50	1·02
May	31·5	1·010	63·5	4' 4"	8·7	17·94	5·46	..	1·6	55·51	10·50	0·88
June	31·0	1·005	57·0	4' 6"	8·9	1·09	4·97	..	2·4	52·15	10·28	0·72
July	30·5	1·005	57·0	5' 7"	8·7	8·20	3·65	..	2·2	54·90	10·50	0·68
August	32·0	·005	50·0	3' 6"	8·6	9·78	4·83	..	2·4	54·90	12·50	0·66
September	30·0	1·010	46·0	3' 0"	8·6	23·61	2·00	..	2·0	51·85	12·50	0·72
October	28·0	1·015	73·0	4' 0"	8·6	20·64	3·71	..	1·8	52·02	10·50	0·65
November	27·5	1·015	70·5	3' 8"	8·6	22·62	4·13	..	1·5	51·85	10·75	0·68
December	27·0	1·015	77·5	3' 5"	8·4	19·54	4·13	..	1·5	51·85	12·00	0·80
1963— January	26·0	1·015	83·0	3' 2"	8·6	21·98	4·20	..	1·5	53·65	17·00	0·98
February	26·5	1·020	85·0	3' 0"	8·6	26·98	4·23	..	1·6	54·05	18·50	7·00
March	29·0	1·010	81·0	2' 5"	8·7	26·04	4·27	..	2·0	53·30	20·50	..

TABLE No. 19.

Hydrology for 1963–64.

In Adyar Reservoir (S9).

(1)	*April.* (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January* (11)	*February.* (12)	*March.* (13)
Salinity o/oo	21·07	22·01	..	15·04	10·9	10·987	8·516	12·09	15·98	17·52	23·66	14·52
Oxygen cc/L	4·27	4·13	..	3·71	3·76	3·20	4·20	2·74	3·89	3·5	4·0	4·9
pH	8·6	8·8	..	7·8	8·6	8·5	8·1	7·8	8·0	8·4	8·1	8·3
Carbondioxide ppm. ..	..	..	..	..	..	..	..	..	..	..	..	..
Carbonate ppm. ..	1·8	2·25	..	1·5	2·6	2·25	2·5	..	..	2·5	3·0	2·5
Bicarbonate ppm. ..	50·325	50·63	..	50·02	48·27	47·62	48·80	38·13	48·80	48·75	57·95	53·38
Silicate Mgm/l ..	22·0	31·0	..	9·17	22·8	26·25	20·0	12·5	11·67	18·0	20·0	16·5
Phosphate ppm. ..	1·80	4·60	..	..	0·8527	0·954	0·4587	0·4959	0·4104	0·4365	0·4167	0·3532
Temperature °C. ..	32·0	31·0	..	26·5	26·5	26·75	26·0	26·0	26·0	26·0	27°C.	27°C.
Specific gravity ..	1·020	1·020	..	1·010	4·005	1·005	1·004	1·007	1·014	1·022	1·023	1·024
Turbidity cm. ..	78·0	42·0	..	53·0	56·0	61·0	63·5	61·0	54·0	47°CM.	50·0	49·0
Depth	3′ 4″	2′ 0″	..	4′ 4″	4′ 5″	5′1″	5′ 3½″	4′ 9″	5′ 6″	4′ 0″	4′ 2″	4′ 1″

TABLE No. 20.

Hydrology for 1964–65.
Reservoir (S 9).

(1)	*April.* (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November.* (9)	*December.* (10)	*January.* (11)	*February.* (12)	*March.* (13)
Salinity o/oo	11·8	10·8	10·73	7·522	5·993	16·63	12·89	3·694	9·387	11·07	11·63	14·19
Oxygen cc/L	3·6	4·0	3·5	2·63	3·03	3·5	3·5	4·2	2·03	2·38	0·28	0·87
pH.	8·6	8·4	8·1	8·26	8·26	8·0	8·1	7·8	8·1	7·9	8·0	8·1
Carbondioxide ppm ..	..	..	..	..	..	..	..	2·0	4·0	..	..	..
Carbonate ppm. ..	4·0	2·0	3·5	3·0	4·0	4·0	3·5	..	..	2·0	2·0	3·0
Bicarbonate ppm. ..	48·80	45·75	57·50	51·85	53·89	48·80	57·95	39·65	42·70	39·65	51·85	65.57
Silicate Mgm/L ..	10·0	18·0	17·50	15·0	13·4	12·0	10·0	20·0	9·0	15·0	30·0	11·6
Phosphate ppm. ..	0·4099	0·4455	0·3559	0·3539	0·3516	0·3425	0·4034	0·3787	0·3599	0·2315	Trace.	0·27
Temperature °C. ..	30·0	32·0	28·0	25·5	24·4	23·0	25·5	22·0	24·0	26·0	47·0	2·55
Turbidity cm. ..	52·0	51·0	50·0	54·5	58·4	52·0	51·0	43·0	35·5	45·0	1·020	1·026
Specific gravity ..	1·026	1·028	1·027	10·27	1·025	1·024	1·025	1·022	1·025	1·017	29·0	27·5
Depth	4′ 4″	4′ 3″	4′ 3″	4′ 6½″	4′ 10″	4′4″	4′ 3″	3′ 7″	2′ 11½″	3′ 9″	3′ 11″	4′ 0″

TABLE 21.

Hydrology for 1965–66.

Reservoir (*S*9).

	April 1965.	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December* 1966.	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Salinity o/oo	8·894	10·033	7·958	6·059	4·788	4·788	4·49	5·366	..	..	..	..
Oxygen cc/L	0·98	1·84	3·08	0·28	4·62	0·56	0·14	0·49	..	..	..	..
pH.	8·0	8·05	8·1	8·0	8·0	8·0	8·8	8·2	..	..	..	..
Carbondioxide ppm. ..	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	..	..	..
Bicarbonate ppm. ..	45·75	50·38	57·95	57·95	61·0	51·85	42·7	45·03	..	..	..	..
Silicate Mg/L	9·1	13·5	13·5	12·0	30·0	20·0	8·0	12·5	..	..	..	..
Phosphate ppm. ..	0·375	0·36	0·38	0·385	0·4237	42·0	..	..	..	..	..	..
Temperature °C ..	27·5	31·0	28·5	24·0	23·0	24·0	20·0	20·5	..	..	..	..
Specific gravity ..	1·027	1·030	1·028	1·019	1·018	1·024	1·018	1·018	..	..	..	..
Turbidity cm. ..	27·0	21·5	18·5	13·0	20·0	21·0	21·0	22·5	..	..	..	.
Depth	4′4″	4′3″	4′1″	4′4″	5′0″	5′	4′8″	4′6″	..	..	..	..
Carbonate ppm. ..	5·0	4·5	4·5	5·0	4·0	5·0	24·0	27·0	..	..	..	..

TABLE 22.

Hydrology for 1959–1960.

In the Adyar River (*S*. 10).

Month.	*Temperature.*	*Specific gravity.*	*pH.*	*Salinity* %o.	*Oxygen cc/L.*	*Carbondioxide ppm.*	*Carbonate ppm.*	*Bicarbonate ppm.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1959—								
November	25·0 C	1·001	8·4	15·63	4·06	Nil.	1·5	25·62
December	24·5 C	1·001	8·4	16·80	4·825	Nil.	3·0	22·25
1960—								
January	25·5 C	1·010	8·6	25·625	4·36	Nil.	3·3	22·57
February	24·0 C	1·016	8·7	26·75	4·06	Nil.	3·0	19·21

TABLE 23.

Hydrology for 1960–61.

Adyar river (S 10) in stock pond.

Months. (1)	*Temperature* °*C.* (2)	*Specific gravity.* (3)	*Turbidity cms.* (4)	*pH.* (5)	*Salinity* %o. (6)	*Carbondi-oxide ppm.* (7)	*Carbonate ppm.* (8)	*Bicarbonate ppm.* (9)	*Oxygen cc/L.* (10)	*Silicats mgm/L.* (11)
1960—										
September	27·5 c.	1·020	44 cm.	8·7	29·05	..	..	..	4·34	32·9
	20·0	1·020	35	7·4	5·275	..	..	..	4·62	20·0
October	29·0	1·020	64 cm.	8·2	21·35	..	..	..	3·78	18·8
	27·0	1·010	52 cm.	7·4	3·231	2·0	...	..	3·15	10·0
November	26·0	1·001	22 cm.	7·2	Nil.	3·3	..	..	3·78	6·5
	26·5	1·001	77 cm.	8·0	12·38	Nil.	..	..	4·20	8·0
December	25·5	1·001	47·5	7·6	Nil.	..	..	..	4·15	13·75
	26·0	1·001	44 cm.	7·6	6·71	2·0	..	..	3·99	12·50
1961—										
January	26·5	1·001	43 cm.	7·4	2·159	..	..	..	3·99	12·00
	26·0	1·010	60·5	8·6	14·47	1·1	..	..	4·27	15·0
February	27·0	1·012	56·0	8·6	11·85	..	..	..	4·06	12·5
	28·0	1·012	170·0	8·6	11·85	..	..	..	3·50	55·5
March	27·0	1·012	38 cm.	8·6	9·569	..	3·6	23·79	4·62	17·5
	29·0	1·012	28	8·8	19·09	..	7·0	27·45	4·97	22·5

TABLE 24.

Hydrology for 1961–62.

Adyar River (S 10).

Months.	*Temperature °C.*	*Specific gravity.*	*Turbidity cm.*	*pH.*	*Depth.*	*Salinity o/oo.*	*Carbondioxide ppm.*	*Carbonate ppm.*	*Bicarbonate ppm.*	*Oxygen cc/L.*	*Silicate mg/L.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1961.—											
April	30·25	1·020	53·5	8·5	4′	10·17	..	5·0	49·5	3·29	35·0
May	31·8	1·018	42·5	8·3	3′8″	21·16	..	2·4	6·6	4·55	18·3
June	30·5	1·012	66·5	8·3	4′2″	4·25	..	2·7	13·25	5·0	16·9
July	28·5	1·003	65·0	8·0	4′1″	..	..	3·3	22·5	4·97	13·0
August	23·5	1·001	42·5	8·1	3′3″	..	..	1·5	23·5	4·09	16·66
September	50·5	1·010	51·5	8·0	3′2″	5·0	2·0	..	26·25	3·625	5·25
October	51·75	1·001	41·0	8·0	3′10″	2·016	1·6	..	28·03	5·30	3·50
November	29·8	1·001	50·5	8·0	4″	6·53	..	2·0	46·0	6·46	4·25
December	28·0	1·010	44·0	8·2	3′6″	2·35	1·8	..	44·0	4·34	6·25
1962—											
January	27·25	1·010	30·5	6·2	2′5″	12·08	..	1·5	44·4	6·12	9·0
February	28·1	1·010	48·8	8·5	3′2″	13·69	..	1·5	41·20	4·34	8·41
March	31·0	1·020	62·5	8·8	4′1″	12·96	..	1·5	47·84	7·44	13·0

Table 25.

Hydrology of Adyar Estuary S (10)—Zone A for 1962–63.

Months. (1)	Temperature (°C.). (2)	Specific gravity. (3)	Turbidity (cm.). (4)	Depth (feet). (5)	pH. (6)	Salinity (o/oo). (7)	Oxygen (cc/L.) (8)	Carbon-dioxide (ppm.) (9)	Carbonate (ppm.) (10)	Bicarbonate (ppm.) (11)	Silicate. (mg./L.) (12)	Phosphate (ppm.) (13)
1962—												
April	32·5	1·015	32·5	3′11½″	8·6	10·06	6·37	..	1·5	49·41	10·50	0.9
May	31·5	1·015	66·5	4′2″	8·2	13·49	5·74	..	1·2	50·325	10·50	0·70
June	31·0	1·002	58·0	4′9″	8·9	7·95	4·90	..	1·5	49·71	10·75	0·77
July	30·5	1·002	57·0	4′6″	8·8	7·00	3·92	..	1·8	53·375	10·50	0·68
August	32·0	1·002	51·0	3′6″	8·6	7·463	4·76	..	3·0	53·375	12·50	0·68
September	30·0	1·010	47·5	3′0″	8·6	23·07	3·50	..	1·8	50·325	12·00	0·65
October	28·0	1·010	79·0	4′2″	8·6	20·37	4·00	..	1·3	51·85	10·50	0·67
November	27·0	1·010	71·5	4′2″	8·6	20·14	4·20	..	1·6	50·325	10·00	0·60
December	27·0	1·010	79·0	4′0″	8·6	18·17	4·13	..	1·5	50·325	11·25	..
1963—												
January	26·0	1·015	79·5	3′4″	8·6	22·63	4·10	..	1·5	51·85	15·00	..
February	26·5	1·015	87·0	3′1″	8·5	27·96	4·16	..	1·8	54·05	18·50	1·20
March	29·0	1·020	84·0	3′0″	8·7	25·54	4·20	..	2·0	54·05	20·25	..

TABLE 26.

Hydrology of Adyar River (S 10) for 1963–64.

	1963.									1964		
	April.	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Salinity (o/oo)	22·84	22·42	12·63	14·62	12·12	8·429	12·09	16·82	16·283	13·82	15·03	10·5
Oxygen (cc/l)	4·27	4·20	..	4·20	3·32	3·75	2·25	2·61	3·37	4·48	3·6	4·2
pH	3·6	8·8	..	8·5	8·6	8·5	8·0	7·9	8·1	8·5	8·1	8·3
Carbondioxide (ppm).	..	..	..	..	..	..	..	3·0	2·0	..	..	..
Carbonate (ppm.)	3·0	3·0	..	3·0	3·0	2·5	3·0	Nil.	Nil.	2·5	2·0	2·5
Bicarbonate (ppm.)	55·51	53·30	..	53·83	49·97	52·76	41·275	26·60	49·81	45·7	57·95	50·33
Silicate (Mg/l)	30·0	39·0	..	9·0	12·22	21·25	17·5	14·0	17·67	15·0	18·0	17·0
Phosphate (ppm)	1·80	1·60	..	0·25	0·4088	0·25	0·8563	0·4266	0·4164	0·4001	0·4237	0·3616
Temperature (°c)	32·00	31·0	..	26·5	26·5	26·0	26·0	26·0	26·0	26·0	26·0	27·0
Specific gravity	1·020	1·020	..	1·010	1·005	1·005	1·004	1·007	1·014	1·002	1·023	1·024
Turbidity (Cm)	77·0	40·5	..	53·5	58·7	52·0	64·5	58·5	55·7	48·5	51·0	50·0
Depth	3′0″	2′ 0″	..	4′ 6″	4′ 10″	5′ 5″	5′ 4½″	4′ 10½″	4′ 8″	4′½″	4′ 3″	4′ 2″

TABLE 27.

ydrology of Adyar River (S 10) for 1964–65.

										1965		
	April.	*May*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Salinity (o/oo)	9·813	90·66	9·701	7·075	4·708	17·91	7·145	3·557	11·266	9·683	8·594	11·00
Oxygen (cc/L)	3·4	4·2	3·5	3·29	2·8	4·2	4·03	4·7	2·04	2·24	2·8	1·26
pH	8·6	8·2	8·4	8·3	8·4	8·1	8·3	7·8	8·1	8·0	8·2	8·1
Carbondioxide (ppm.)	..	..	..	..	..	..	..	4·0	..	..	..	..
Carbonate (ppm.)	3·0	3·0	3·5	3·0	3·0	3·0	4·0	..	2·5	3·0	3·0	3·5
Bicarbonate (ppm.)	48·80	51·85	53·38	51·85	54·9	51·85	42·70	45·75	40·68	30·50	48·80	47·27
Silicate (mg/L)	15·0	15·0	15·0	14·0	17·0	15·0	10·0	18·0	10·0	10·0	10·0	17·5
Phosphate (ppm.)	0·3334	0·4310	0·3592	33·78	0·3413	0·3522	0·3497	0·3732	0·4049	..	Traces.	0·25
Temperature (°C.)	30·0	32·0	28·0	25·5	24·0	23·0	25·5	22·0	24·0	27·0	29·0	27·0
Turbidity (cm.)	51·0	55·0	53·0	56·0	60·0	55·0	50·5	35·0	48·0	48·0	48·0	40·0
Specific gravity	1·026	1·028	1·027	1·026	1·025	1·023	1·025	1·022	1·025	1·019	1·020	1·026
Depth (in centi metres)	18·16	17·15	15·75	15·12	16·51	15·4	16·51	19·18	20·7	18·55	17·78	16·13

TABLE 28.

Hydralogy Adyar River of S 10) for 1965–66.

										1966.		
	April	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*	*January.*	*February.*	*March.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Salinity (o/oo)	6·438	7·74	5·9	10·85	3·421	3·714	3·812	5·913	..	..	..	..
Oxygen (cc/L)	3·92	2·24	2·73	1·12	4·76	0·7	0·28	1·4	..	..	..	..
pH.	8·0	8·0	8·0	8·0	8·0	8·0	8·8	8·4	..	..	..	..
Carbondioxide (ppm.)	..	..	..	..	..	..	..	..	..	..	..	..
Carbonate (ppm.)	4·5	2·5	4·0	4·0	4·0	5·0	24·0	15·6	..	..	..	..
Bicarbonate (ppm.)	45·75	45·75	47·27	42·7	51·85	36·6	36·6	50·8	..	..	..	..
Silicate (mg./L)	12·5	11·0	11·0	11·0	20·0	15·0	7·0	9·5	..	..	..	..
Phosphate (ppm.)	0·375	0·365	0·38	0·376	0·6126	4·1	..	..	..	..	..	..
Temperature (°c)	29·0	31·0	27·5	25·0	22·0	24·0	19·0	19·5	..	..	..	..
Specific gravity	1·027	1·030	1·026	1·030	1·019	1·024	1·017	1·016	..	..	..	..
Turbidity (cm.)	27·5	24·5	20·0	17·0	21·0	20·0	23·0	23·5	..	..	..	..
Depth	4′9″	5′ 0″	4′ 5″	4′ 11″	5′ 1″	5′ 5″	5′ 4″	4′ 8″	..	..	..	..

TABLE 29.

Hydrology for 1963–64.

		Estuarine Fish Farm.			Reservoir		River	Nurseries and Ponds.		
Chemical contents.	*Months of highest value.*	*Months of lowest value.*	*Range.*	*Months of Highest value.*	*Months of lowest value.*	*Range.*	*Months of highest value.*	*Months of lowest value.*	*Range.*	*Range.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Salinity o/oo	April, May and June.	October, November and December.	17·17 to 28·20	April to June.	August to October.	8·51 to 23·6	April to June.	September to November.	8·429 to 22·84	6·224 to 12·20
Oxygen cc/L	July, August and September.	October, November and December.	2·41 to 4·34	April to June.	October to December.	2·71 to 4·27	April to June.	October to December.	2·25 to 4·27	3·64 to 6·58
PH.	April, May and June.	July, August and September.	7·6 to 8·4	April to June.	September, October and November.	7·8 to 8·8	May to July.	October to December.	7·9 to 8·8	8·0 to 8·1
Carbondioxide ppm.	January, February and March.	October, November and December.	Nil to 3·5	January to March.	October to December.	Nil to 2·0	December.	November.	Nil to 3·0	Nil.
Carbonate ppm.	July August and September.	April, May and June.	Nil to 4·0	April to June.	July to September.	Nil to 4·0	April to June.	October to December.	Nil to 3·0	1·0 to 3·0
Bicarbonate ppm.	April, May and June.	January, February and March.	18·30 to 51·85	June to August.	October to December.	38·13 to 57·95	February to April	October to December.	42·76 to 53·83	42·70 to 64·05
Silicate Mgm/L	April, May and June.	October, November and December.	8·0 to 32·0	April to June.	October to December.	9·17 to 34·0	April to June.	October to December.	9·00 to 40·0	24·0 to 30·0
Phosphate ppm.	April, May and June.	October, November and December.	0·25 to 1·75	April to June.	October to December.	0·3532 to 1·8	April to June.	October to December.	0·2 to 1·8	0·3651 to 0·4237

TABLE 30.

Hydrology for 1963–64.

	Estuarine Fish Farm			Reservoir			River	Nurseries and Ponds.		
	Months of highest value.	*Months of lowest value.*	*Range.*	*Months of higest value.*	*Months of lowest value.*	*Range.*	*Months of highest value.*	*Months of lowest value.*	*Range.*	*Range*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Water Temperature oC.	April to June.	October to December.	25·5 C to 32·0	April to June.	October to December.	26·0 to 32·0	April to June.	October to December.	26·0 to 32·0	26·0 to 34·0
Specific gravity	January, February and March.	October to December.	1·005 to 1·023	January to March.	October to December.	1·004 to 1·024	January to March.	October to December.	1·004 to 1·024	1·002 to 1·024
Turbidity cm.	July to December and September.	January to March.	44·0 to 79·0	July to September.	January to March.	47·0 to 78·0	July to September.	January to March.	47·0 to 78·0	25·0 to 41·0
Depth	August, September and October.	January to March.	3′ 6″ to 5′ 4″	August to October.	January to March.	2′ 0″ to 5′3½″	August to October.	January to March.	2′ 0″ to 5′ 3½″	2′ 1″ to 3″ 5″

TABLE 31.

Soil contents of stock pond S1 for 1964–65.

In ppm.	*April 1964 S1.*	*May S1.*	*June S1.*	*July S1.*	*August S1.*	*September S1.*	*October S1.*	*November S1.*	*December S1.*	*January S1.*	*February S1.*	*March 1965 S1.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Chloride ppm.	150	150	150	150	150	200	5	Trasees.	200	200 or more.	200	Above 200.
Calcium ppm.	..	..	..	..	..	..	..	..	..	..	..	..
Sulphate –	..	..	..	..	..	..	..	..	..	..	..	..
Act. –	2½	5	5	1	2½	1	2½	..	2	2½	2½	1
Phosphate Act	..	..	..	..	..	..	..	..	2	2½	1	1
Iron ppm. Act.	..	..	..	..	..	..	..	..	..	..	..	..
Res. .. –	..	..	..	..	..	..	..	..	2	Traces.	..	.
Aluminium –	..	..	..	..	..	..	..	..	3	..	3	
Ammonium ppm.	..	..	..	..	..	..	..	..	2	2	All.	Traces.
Magnesium –	..	..	..	..	..	..	..	..	..	..	..	..
pH. .. –	..	..	..	..	..	8·0	7·2	6·0	6·5	7·5	Above 8·0	Above 8·0

TABLE 32.

Soil Analysis for the year 1966.

Pond I.

	April.	*May.*	*June*	*July.*	*August.*	*September.*	*October.*	*November.*	*December.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ammonium ppm.	Nil.	Nil.	3	Nil.	Nil.	Nil.	..	Nil.	..
Phosphate Ac.	2½	1	1	2½	1	1	..	1	..
ppm' Re.	1	1	1	1	2½	1	..	1	..
Calcium ppm.	..	Nil.	Nil.	Nil.	Nil.	Nil.	..	20	..
Sulphate ppm.	..	Nil.	Nil.	Nil.	Nil.	Nil.	..	20	..
Iron Ac.	Traces.	Nil.	Nil.	Nil.	Nil.	2	..	1	..
Re.	Nil.	..	..	1	2	Nil.	..	2	.
Aluminium ppm.	3	3	Nil.	Nil.	Nil.	Traces.	..	10	..
Magnesium ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	..	..
Chloride pp.m.	200	Nil.	Nil.	Nil.	Nil.	Nil.	..	Nil.	..
pH.	Above 8·0	Above 8·0	Above 8	Above 80	Above 7·5	Above 8·0	..	Above 8·0	..

TABLE 33.

Soil Analysis for the year 1965.

April to December 1965.

Pond 9.

	April.	*May.*	*June.*	*July*	*August.*	*September.*	*October.*	*November.*	*December.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ammonium ppm.	..	3	Nil.	Nil.	Nil.	Nil.	..	Nil.	..
Phosphate Ac.	Nil.	2½	2¼	2½	2½	1	..	1	..
ppm Re.	..	1	1	2½	2½	1	..	1½	..
Calcium ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	Nil.	..
Sulphate ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	Nil.	..
Iron Ac.	Nil	Nil.	Nil.	1	4	Nil.	..	..	..
ppm. Re.	..	..	..	1	2	..	..	..	..
Aluminium ppm.	Taraces	Nil.	Nil.	Nil.	Nil.	Nil.	..	10	..
Magnesium ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	Nil.	..
Chloride ppm.	5	50	50	20	150	50	..	20	..
pH.	Above 8·0	Above 8	Above. 8·0	Above. 8·0	Above 8·0	Above 8·0	..	Above 8·0	..

TABLE 34.

Soil Analysis for the year 1965.

April to December 1965.

Pond 10.

(1)	*April.* (2)	*May.* (3)	*June.* (4)	*July.* (5)	*August.* (6)	*September.* (7)	*October.* (8)	*November* (9)	*December.* (10)
Ammonia ppm.	..	3	Nil.	Nil.	Nil.	Nil.	..	Traces.	..
Phosphate Ac.	..	2½	2½	2½	2½	1	..	1	..
Re.	Nil.	1	1	1	2½	1	..	1	..
Calcium ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	10	..
Sulphate ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	11	..
Iron ppm. Ac.	Nil.	Nil.	Nil.	2½	1	Nil.	..	Traces.	..
Re.	Nil.	Nil.	Nil.	1	2	Nil.	..	2	..
Aluminium ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	8	..
Magnesium ppm.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	..	..	..
Chloride ppm.	5	20	200	5	150	50	..	10	..
pH.	Above 8·0	Above 8·0	Above 8·0	Above 8·0	Above. 8·0	Above 8·0	..	Above 8·0	..

TABLE 35.

Availabilty of Larvae-Penaeus Indicus, Penaeus carinatus.

From January 1960 to June 1961.

January 1960	Prawn post larvae present.
February 1960	Few post larvae available.
March 1960	Nil.
April 1960	Penaeus carinatus larvae available.
May 1960	Prawn post larvae available.
June 1960	Prawn post larvae available.
July 1960	Nil.
August 1960	Nil.
October 1960	Prawn post larvae available after 15–10–1960.
November 1960	Penaeus indicus post larvae and fry available size range 10 mms. to 63 mms.
December 1960	Penaeus indicus and Penaeus carinatus post larvae availalbe. Size range 10 mm. to 36 mm.
January 1961	Penaeus indicus and Penaeus carinatus post larvae present 10 mm. to 31 mm. size range.
February 1961	Penaeus indicus and Penaeus carinatus post larvae available.
March 1961	Penaeus indicus and Penaeus carinatus post larvae present.
April 1961	Penaeus indicus post larvae present.
May 1961	Penaeus indicus post larvae present.
June 1961	Penaeus indicus post larvae present.

N.B.—Bar remained open till May 1961 enabling entry of prawn larve.

TABLE 36.

Random Sampling of Prawns from the Estuarine Catches during 1964–65.

Month.	*Number of examined.*	*Species examined.*	*Number of each species.*	*Nos. Male.*	*Nos. Female.*	*Undifferentiated Nos.*	*Size range mm.*	*Weight range grams.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
April 1964	66	Penaeus indicus	38	6	5	16	93—189	4·5—38·0
		Penaeus carinatus	25	22	16	..	97—210	11·5—92·5
		Metapenaus monoceros	3	2	1	..	72—84	1·5—3·5
May 1964	..	Nil.	..	..	..	..	....	....
June 1964	8	Penaeus indicus	3	1	2	..	104—130	4·5—16·0
		Penaeus carinatus	4	1	3	..	128—184	13·0—34·0
		Metapenaeus monoceros	1	..	1	..	109	17·0
July 1964	1	Metapenaeus dobsoni	1	..	1	..	106	17·0
August 1964	20	Penaeus indicus	9	4	5	..	132—146	31·0—42·5
		Penaeus carinatus	10	4	6	..	138—186	33·5—75·0
		Metapenaeus dobsoni	1	..	1	..	170	28·0
September 1964	124	Penaeus indicus	110	7	4	99	15—147	1·0—35·5
		Penaeus carinatus	7	3	..	4	16—176	1·0—27·5
		Metapaneus monoceros	1	1	..	..	107	10·5
		Metapenaeus dobsoni	6	..	1	5	22—82	1·0—4·5
October 1964	884	Penaeus indicus	771	..	..	771	36—112	35—3·7
		Metapenaeus dobsoni	111	..	..	111	45—78	1·0—1·5
		Metapenacus monoceros	2	1	..	1	72—126	1·0—4·5

TABLE 37.

Randon sampling of Prowns from the estuarine catches during 1964–65 – cont.

Month.	*Number of examined.*	*Species examined.*	*Number of each species.*	*Nos. Male.*	*Nos. Female.*	*Undifferentiated Nos.*	*Size range mm.*	*Weight range grams.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November 1964	569	Penaeus indicus	553	76	127	350	41—116	1·4—8·0
		Penaeus carinatus	1	..	..	..	121	15·5
		Metapenaeus monoceros	1	..	1	..	74	1·7
		Metapenaeus dobsoni	14	1	..	13	54—76	1·4—4·2
December 1964	232	Penaeus indicus	130	47	64	4	70—126	3·2—12·5
		Penaeus carinatus	4	..	..	4	26—100	4·0—9·0
		Metapenaeus monoceros	86	..	..	86	25—89	0·7—1·8
		Metapenacus dobsoni	12	..	..	12	51—55	2·0
January 1965	490	Penaeus indicus	195	76	86	34	47—167	2·5—31·5
		Penaeus carinatus	8	5	3	..	85—174	5·0—42·5
		Metapenaeus Monoceros	14	3	7	4	36—92	1·7—6·0
		Metapenaeus dobsoni	273	36	41	194	23—90	0·43—3·5
February 1965	590	Penaeus indicus	421	82	165	174	46—159	1·4—29·5
		Penaeus carinatus	4	2	2	..	115—216	8·5—89·0
		Metapenaeus monoceros	7	1	4	2	58—91	1·3—1·3
						303	40—96	1·3—5·7

TABLE 38.

Random sampling of Prawns from the Estuarine catches during 1964–65—cont.

Month.	*Number of examined.*	*Species examined.*	*Number of each species.*	*Nos. Male.*	*Nos. Female.*	*Undiferentiated Nos.*	*Size range.*	*Weight range.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
							MM.	GMS.
1965— **March**	192	Penaeus indicus	90	33	50	7	76—155	5·3—2·2
		Penaeus carinatus	12	4	8	..	115—168	12·0—4·6
		Metapenaeus dobsoni	86	17	28	41	58—84	2·6—5·5
		Metapenaeous monoceros	4	..	..	4	....	....

Total, examined—3,176 prawns.

TABLE 39.

Percentage size range and sex ratio of Penaeus indicus in random sampling from the Adyar creek during 1959–60.

Month. (1)	Percentage in total prawn catch. (2)	Size range. (3) MM.	Sex ratio. Male. (4)	Sex ratio. Female. (5)	Dominant. Size. (6) MM.	Dominant. Group (7) MM.
1959—						
May		40–70	Sexes undifferentiated.			
June	100	86–112	1	10	98, 99	92– 94
July	85½	78–136	1	2	110–112	101–105
August	90	66–134	1	5	93, 94 110	98–100 110–116
September	96	60–132	1	7	111·112	110–114 85– 89
October	97½	55–125	1	6	70–74 125–130	89, 90 101–107
November	83½	24 - 72	Sexes undifferentiated 39 to 48.			
December	71	46 - 83	Sexes undifferentiated 50 to 60.			
1960—						
January	77	63 - 98	2	7	97, 98	75, 76
February	3	78–111	1	9	111	92
March	81	67–129	1	17	129	87 117, 118

TABLE 40.

Growth Studies of Penaeus indicus in stock pond (S1).

Month.	Length Range. CM.	Length Range. CM.	Weight Range. GMS.	Weight Range. GMS.	Remarks
1963—					
March	6·0	9·0	0·5	4	....
April	5·5	10·3	1·0	10	....
May	6·6	13·0	1·0	13	....
June	5·3	13·0	1·0	22	....
July	6·6	13·8	0·5	20	....
August	6·5	13·8	3·0	25	....
September	10·0	14·7	8·0	33·5	....
October	1·5	..	..	..	Bar opened on 21st October 1963 and closed on 27th October 1963 Larvae appear.
November	1·5	8·4	..	2·5	Bar opened on 5th November 1963.
December	1·1	3·9	..	0·5	....
1964—					
January	1·8	7·1	0·5	1·0	Bar closed on 9th January 1954.
February	5·3	10·0	0·5	6·5	....
March	..	11·4	..	7·0	....

TABLE 41.

Growth Studies of Penaeus carinatus in Stock Pond (S1).

Month.	Length.	Range.	Weight Range.		Remarks.
(1)	(2) MM.	(3) CM.	(4) GMS.	(5) GMS.	(6)
1963—					
March	8·0	13·0	0·5	4	....
April	16·0	17·4	29·0	39	....
May	8·0	18·4	11·5	68	....
June	7·5	18·8	15·	75	....
July	..	..	..	..	Now available.
August	..	..	..	..	Now available.
September	11·9	21·4	36·5	97	....
October	0·9	4·8	0·5	1	Bar opened on 21st October 1963 and closed on 27th October 1963. Natural entry.
November	3·0	7·1	0·5	1	Bar opened on 5th Novemb 1963.
December	2·9	4·0	0·5	1	....
January	3·2	14·2	0·5	20	Bar closed on 9th January 1964.
1964—					
February	9·2	..	7·0	..	Larve stopped appearing.
March	10·0	11·0	9·0	12	....

TABLE 42.

Growth Studies of Penaeus indicus in the Stock Pond (S1).

Month.	Female.		Female.		Male.		Male.	
	Length range.		Weight range.		Length range.		Weight range.	
(1)	(2) MM.	(3) MM.	(4) GMS.	(5) GMS.	(6) MM.	(7) MM.	(8) GMS.	(9) GMS.
1960—								
December	4	83	..	..	..	..	..	..
1961—								
January	79	108	..	..	82	107	..	..
February	101	187	4	38	95	165	8	44
March	72	160	3	43	67	181	5	30
April	125	167	25	60	122	149	30	45
May	136	187	25	60	130	155	25	45
June	140	162	34	55	140	154	32	45
July	145	170	60	90	144	185	65	90
August	130	183	45	90	130	157	45	57
September	148	167	37	65	133	159	26	44
October	125	177	37	65	128	163	31	65
November	164	180	50	60	161	176	45	60
December	130	[illegible]	40	70	162	174	40	50

TABLE 43.

Growth Studies of Penaeus carinatus in Stock Pond (S1).

Month.	*Length range.* *Female.*		*Weight rangel.* *Female.*		*Length range.* *Male.*		*Weight range.* *Male.*	
(1)	(2) MM.	(3) MM.	(4) GMS.	(5) GMS.	(6) MM.	(7) MM.	(8) GMS.	(9) GMS.
1961—								
January	177	177	43	..	..	..	..	..
February	202	202	74	..	177	..	29	..
March	128	225	17	120	108	200	12	70
April	120	..	18	..	190	210	65	95
May	127	240	40	115	135	136	25	40
June	142	197	32	88	145	186	30	68
July	140	195	65	179	113	185	110	115
August	125	240	55	190	203	..	180	..
September	200	..	85	..	160	297	70	115
October	220	251	142	160	110	200	70	95
November	220	237	110	140	200	211	75	85
December	220	233	120	135	198	214	95	105

TABLE 44.

Growth Studies of Metapenaeus dobsoni in Stock Pond (S1).

Month.	*Length range.* *Female.*	*Length range.* *Male.*	*Weight range.* *Female.*	*Weight range.* *Male.*	*Remarks.*
(1)	(2) CM.	(3) CM.	(4) CM.	(5) CM.	(6)
1963—					
April	–	–	–	–	None available.
May	7·2	7·7	2·0	2·5	Bar closed on 4th May 1963. Few available.
June	4·1	8·6	0·25	4·0	Abundant.
July	6·0	8·2	0·5	5·0	Do.
August	6·2	7·9	2·5	3·1	Available in first half.
September	..	..	..	..	Absent.
October	..	..	..	..	Absent. Bar opened on 21st October 1963 and closed on 17th October 1963.
November	2·7	4·4	0·5	0·5	Young available 5th November 1963 opened again.
December	3·1	3·9	0·5	0·5	....
1964—					
January	3·5	6·5	6·5	0·5	Bar closed on 9th January 1964.
February	4·2	6·7	0·5	2·00	....
March	..	..	..	..	None available.
April	–	..	..	..	Do.

TABLE 45.

Food of Penaeus carinatus.

Phyto organisms, name, numbers per cc. range. (1)	(2)	*Zoo organisms, name, numbers per cc. range.* (3)	(4)	*Miscellaneous name, numbers per cc. range.* (5)	(6)
1 Enteromorpha	5	Copepod parts	240	Sand grains.	240
			1,440		2400
2 Navicula	480	Polychaete worms	240		
3 Oscillatoria	240	Gastropod shells	240		
			480		
		Nairs	240–9,840		
		Lamellibranch shells	240		
			13,680		

TABLE 46.

Food of Penaeus indicus.

Phyto organisms, name, numbers per cc. range. (1)	(2)	*Zoo-organisms, name, numbers per c.c. range.* (3)	(4)	*Miscellaneous, name, numbers per cc. range.* (5)	(6)
1 Navicula	720	1 Copepod Parts	960	Sand grains.	..
	27,000				
2 Gyrosigma	720	2 Copepod Hairs	240	....	240
	1680	..	..	...	..
3 Suriella	240	3 Crustacean	420	Digested matter.	
	2,400	Appendages	1,920	....	..
4 Chaetomorpha	720	4 Cypris	240	..	..
	960	....	..	....	—
5 Thalassiosira	240	5 Fish Scale	240	....	..
6 Oscillatoria	240	6 Chitinous Matter	240	....	..
	3,120	....	..	....	..
7 Spirogyra	240	7 Nauplii	240	....	..
	23,040	....	480	....	..
		8 Foraminifera	240	....	..
		9 Brachionus	240	....	..
		10 Nematoda	240	....	..
		11 Peridinium	240	....	..
			3,360	....	..
		12 Euglena	240	....	..
			480	....	—

TABLE 47.

Food of Metapenaeus dobsoni.

Food of Metapeneus dobsoni.

Phyto organisms name. (1)	*Nos. per cc. range.* (2)	*Zoo organisms name.* (3)	*Nos. per cc. range.* (4)	*Miscellaneous name* (5)	*Nos. per cc. range* (6)
Navicula	240—720	Metapenaeus Hairs.	480—10,320	Sand grains ..	480—3,96,000
Chaetomorpha	480—1,200	Crustacean parts ..	240—5,280	....	....
Suriella	240—1,440	....	....	....	....
Oscillatoria	240—480	Euglena	240	....	....
Spirogyra	240—480	....	....	....	....

TABLE 48.

Food of Metapenaeus monoceros.

Phyto organisms name. (1)	*Nos. per cc. range.* (2)	*Zoo organisms name.* (3)	*Nos per cc. range.* (4)	*Miscellaneous name.* (5)	*Nos. per cc. range.* (6)
Gyrosigma	240	....	....	Sand grains	14,400—30,000
Suriella	240	....	....	....	....
Navicula	240—720	....	....	....	....
Spirogyra	240—480	....	....	....	....

TABLE 49.

Prawn landings of the commercial catches of the Adyar estuary from April 1963 to March 1966.

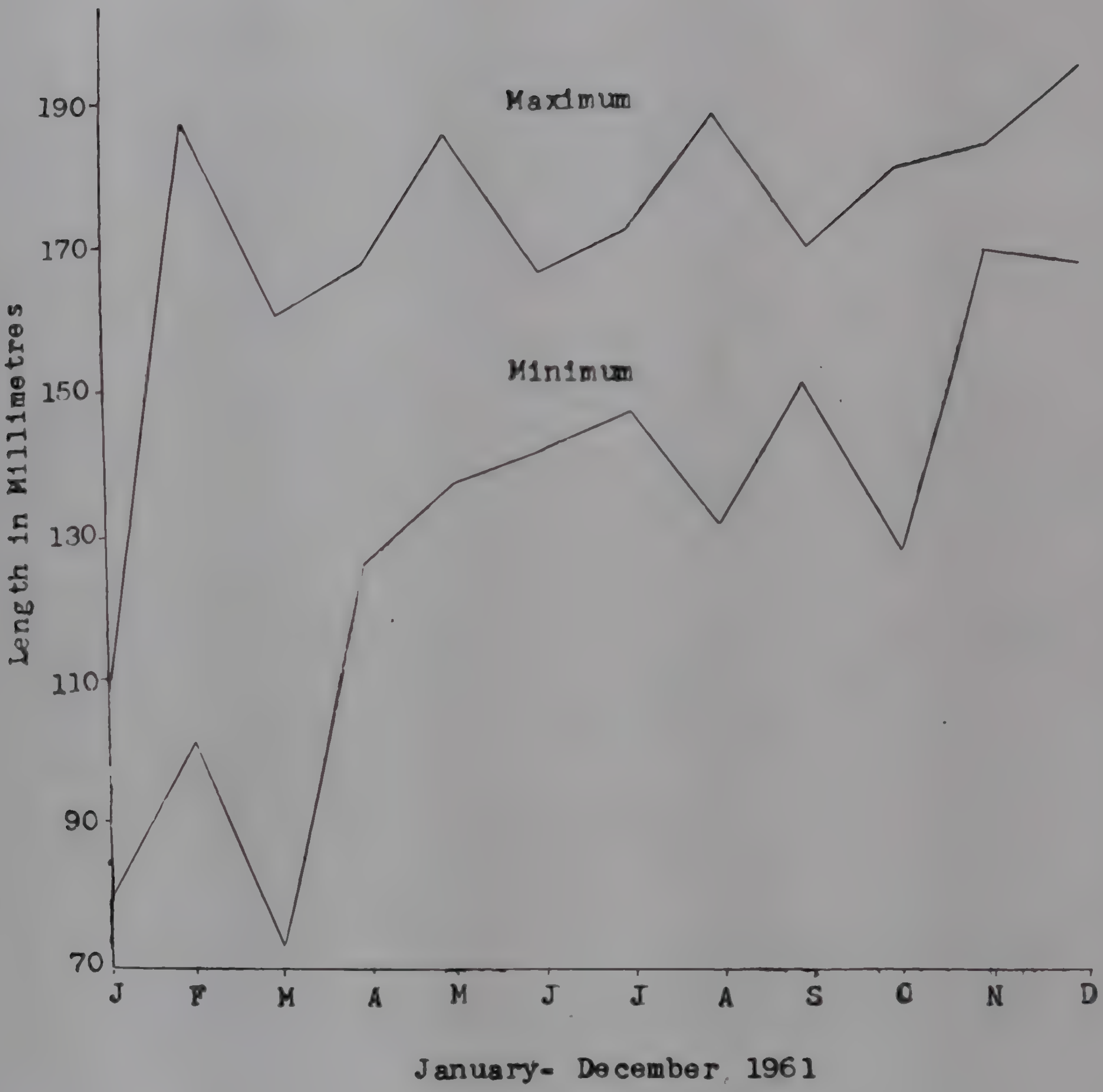
Month. (1)	1963–64. (2)	1964–65. (3)	1965–66. (4)
	KGS.	KGS.	KGS.
April	1,261·0	268·0	87·5
May	2,237·5	171·0	Nil.
June	2,246·0	Nil.	775·0
July	3,752·5	Nil.	350·0
August	237·0	Nil.	632·0
September	482·0	209·5	88·0
October	400·0	8,743·0	165·5
November ..	4,395·0	2,884·0	96·0
December	8,716·0	693·0	78·0
January	4,008·5	565·0	69·0
February	2,938·0	840·5	119·0
March	2,479·0	159·0	47·5
Total ..	33,153·0	14,533·0	2,507·5

TABLE 50.

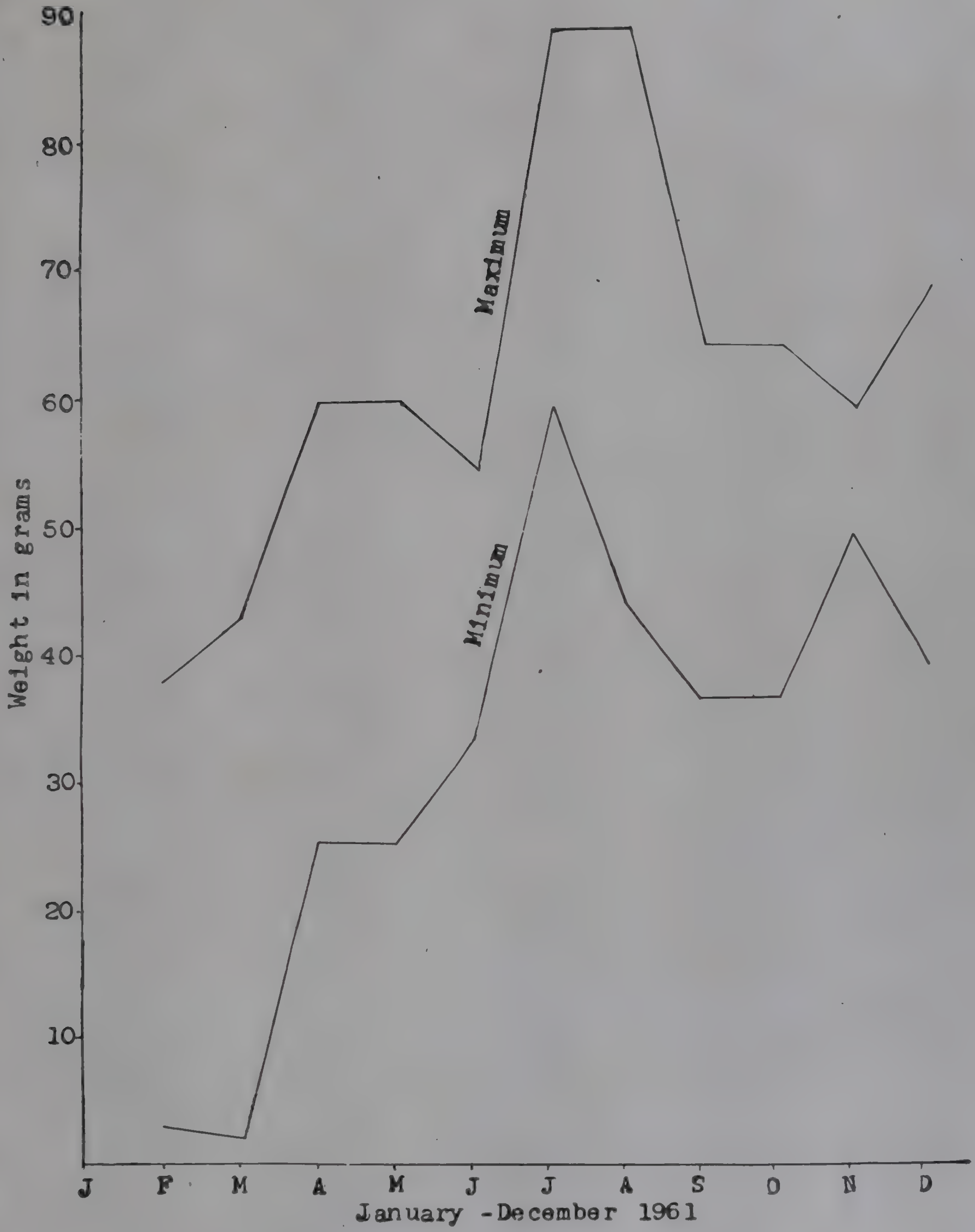
Size range and percentage composition of prawns in the estuarine landings of Adyar during 1963–65.

Months.	1963–64.		1964–65.	
	Size range Cm.	*Percentage in total catch.*	*Size range Cm.*	*Percentage in total catch.*
(1)	(2)	(3)	(4)	(5)
April	9·5—16·2	39	8·7—16·4	3
May	7·4—13·8	57	10·2—17·4	2
June	6·5—12·3	50	...	—
July	7·7—12·4	32	...	...
August	6·5—12·4	15	...	..
September	8·4—11·7	1	3·0—5·2	5
October	10·6—12·4	2	1·3—7·4	86
November	7·0—10·6	9	6·4—7·5	35
December	9·5—12·4	15	9·7—11·3	8
January	6·0—14·0	26	11·3—17·4	10
February	12·6—17·4	18	10·7—16·5	14
March	9·7—15·1	14	11·3—18·6	3

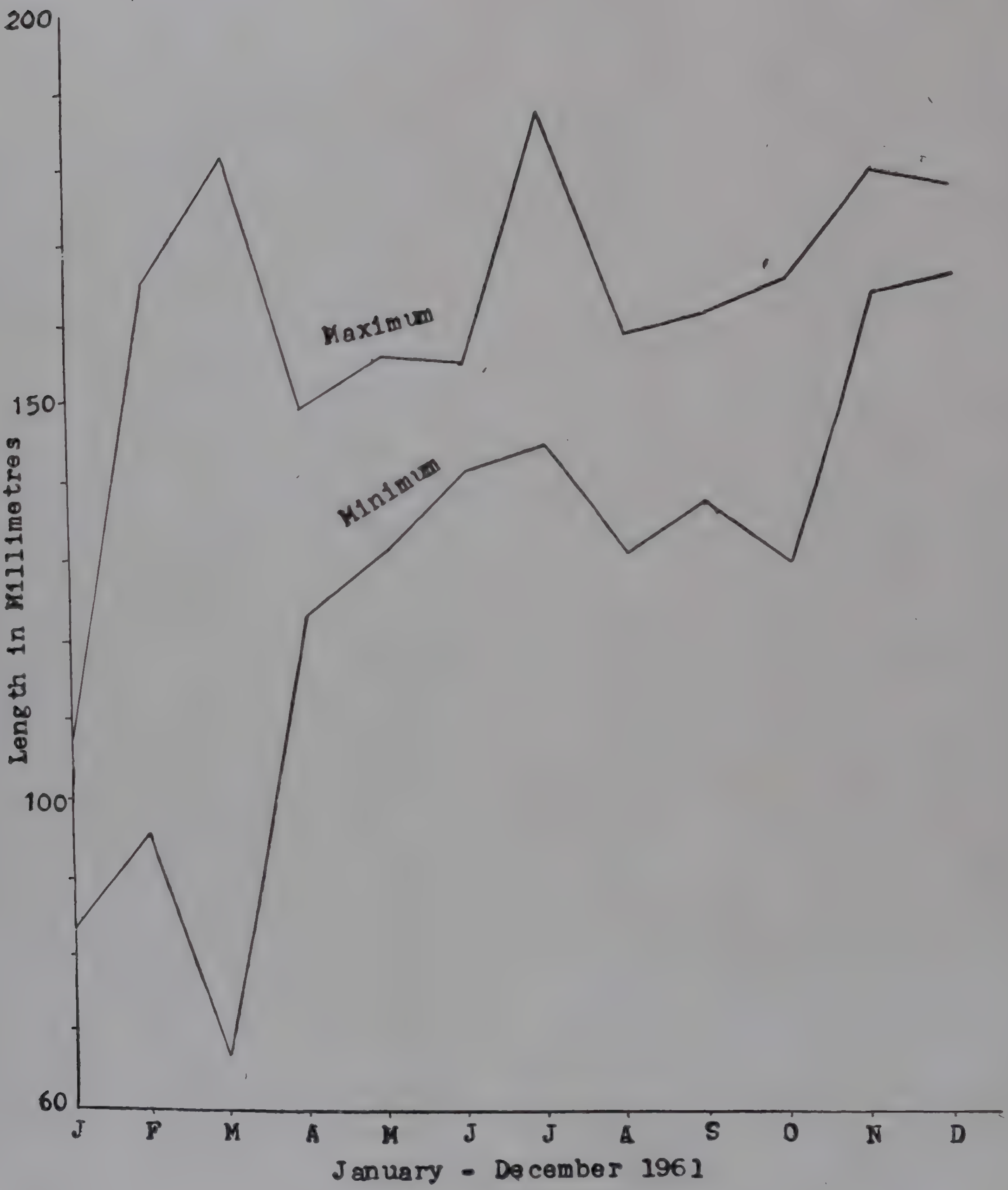
GRAPH 1—GROWTH OF PENAEUS INDICUS (FEMALE) IN LENGTH IN POND S_1 IN 1961.



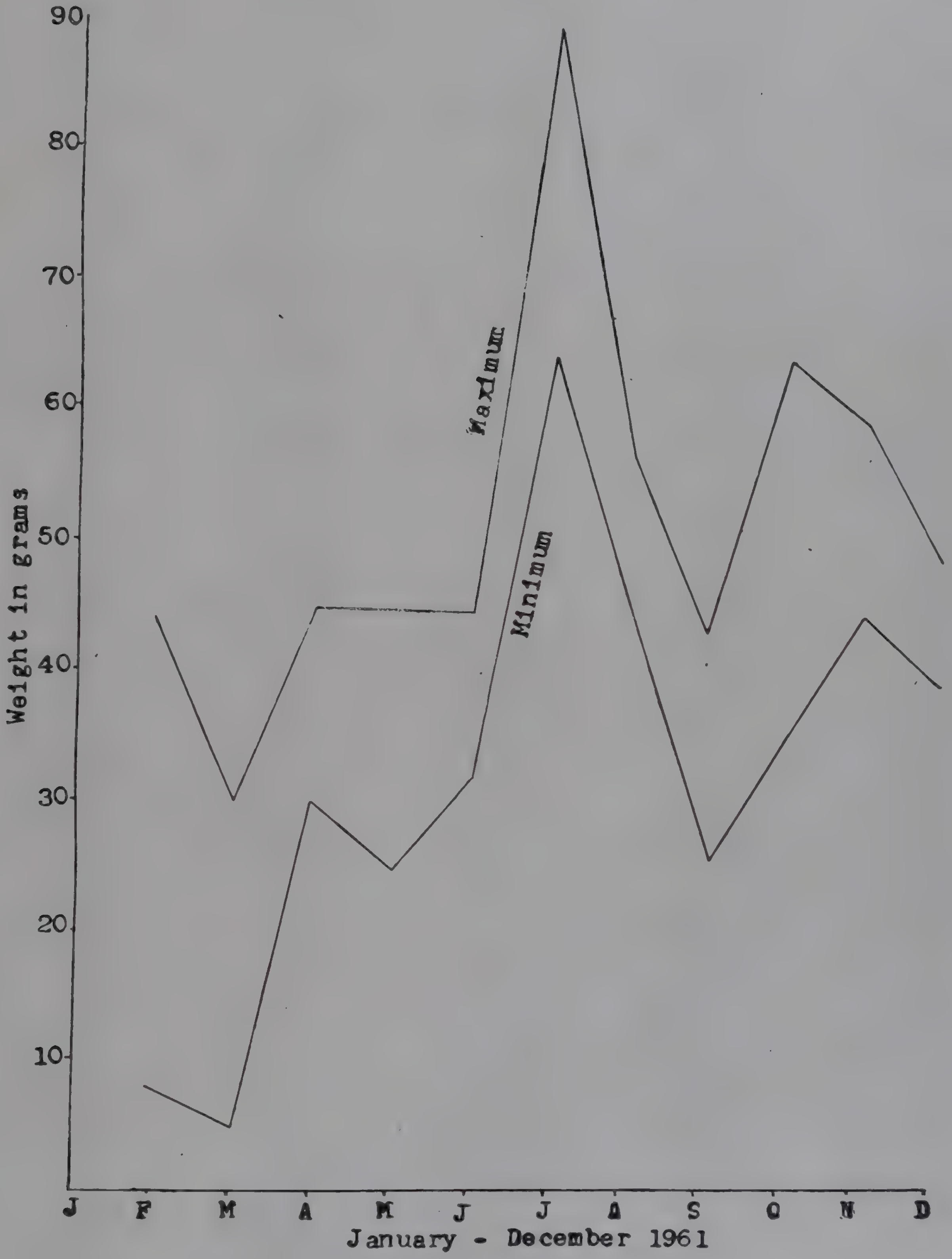
GRAPH 2—GROWTH OF PENAEUS INDICUS (FEMALE) IN WEIGHT IN POND S1 IN 1961



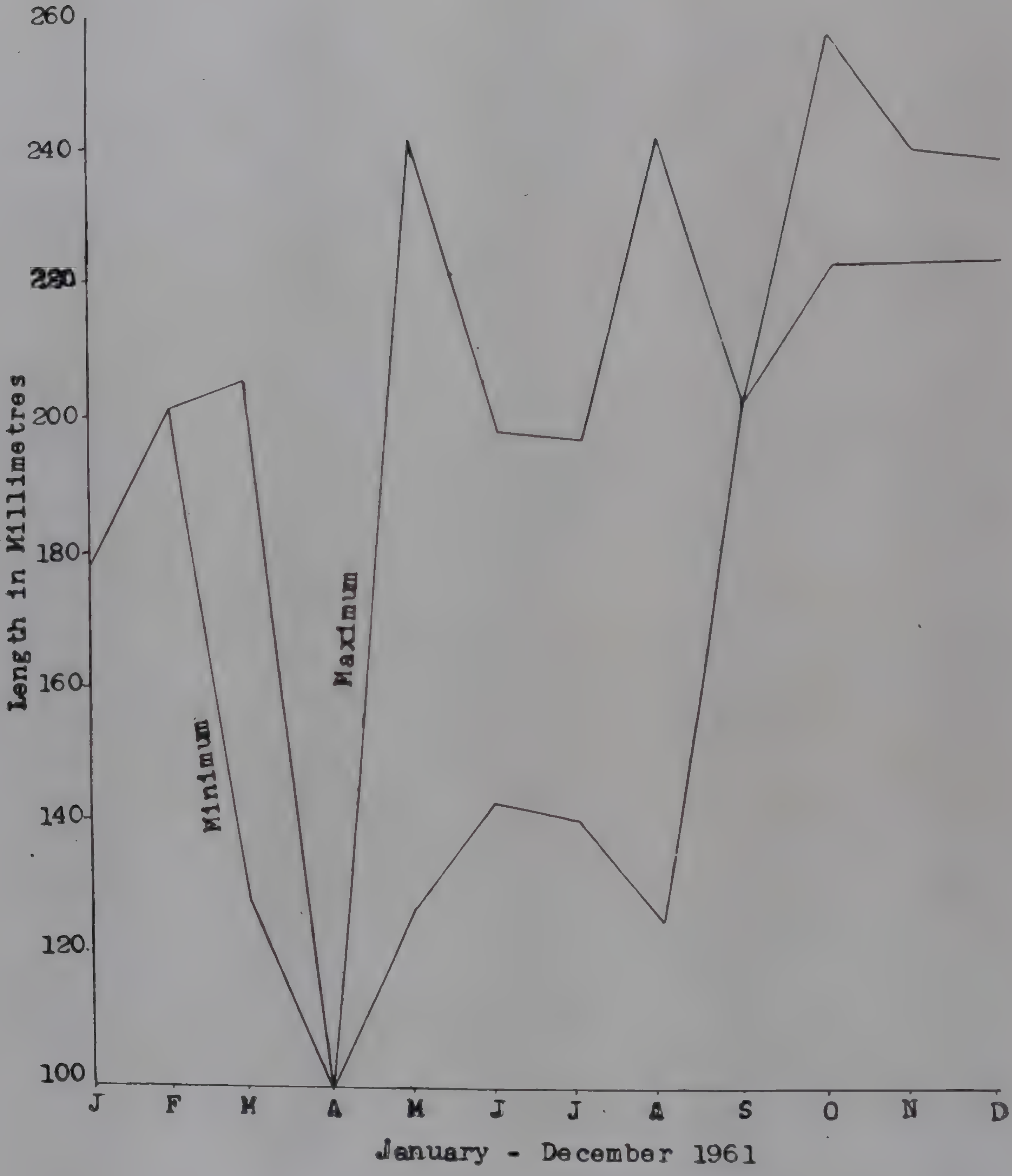
GRAPH 3—GROWTH OF PENAEUS INDICUS (MALE) IN LENGTH IN POND S1 IN 1961.



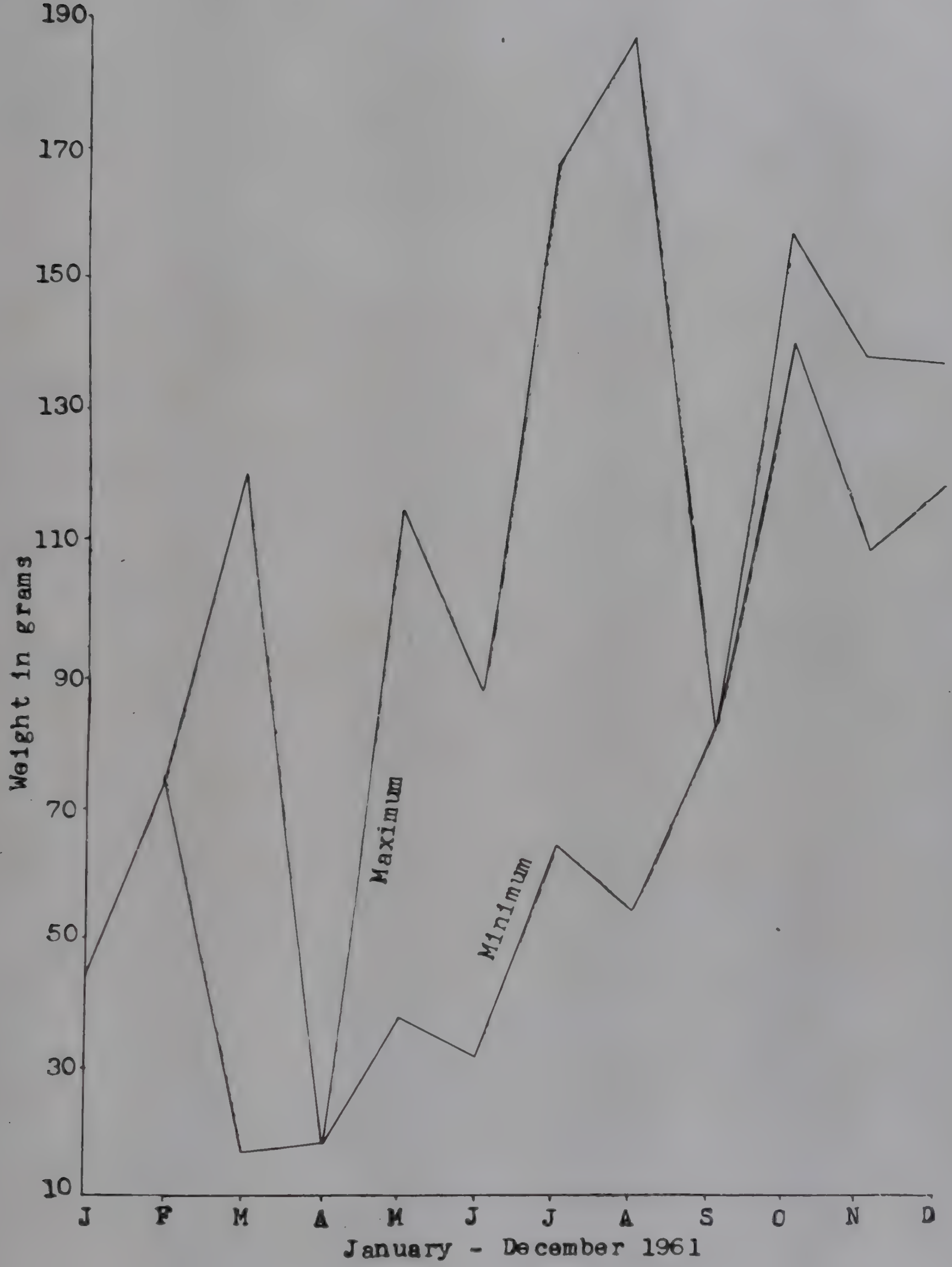
GRAPH 4—GROWTH OF PENAEUS INDICUS (MALE) IN WEIGHT IN POND S1 IN 1961.



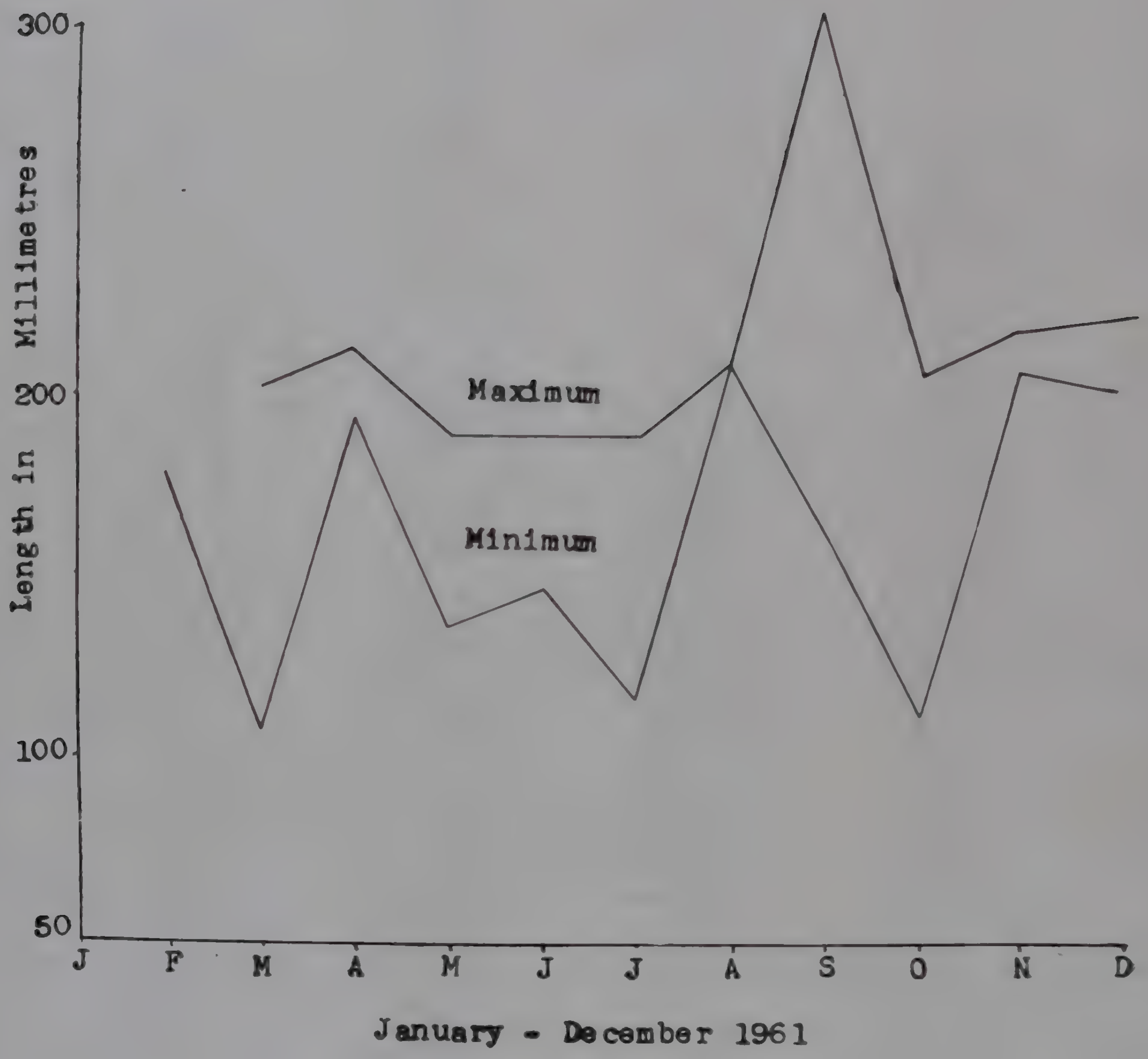
GRAPH 5—GROWTH OF PENAEUS CARINATUS (FEMALE) IN LENGTH IN POND S1 IN 1961.



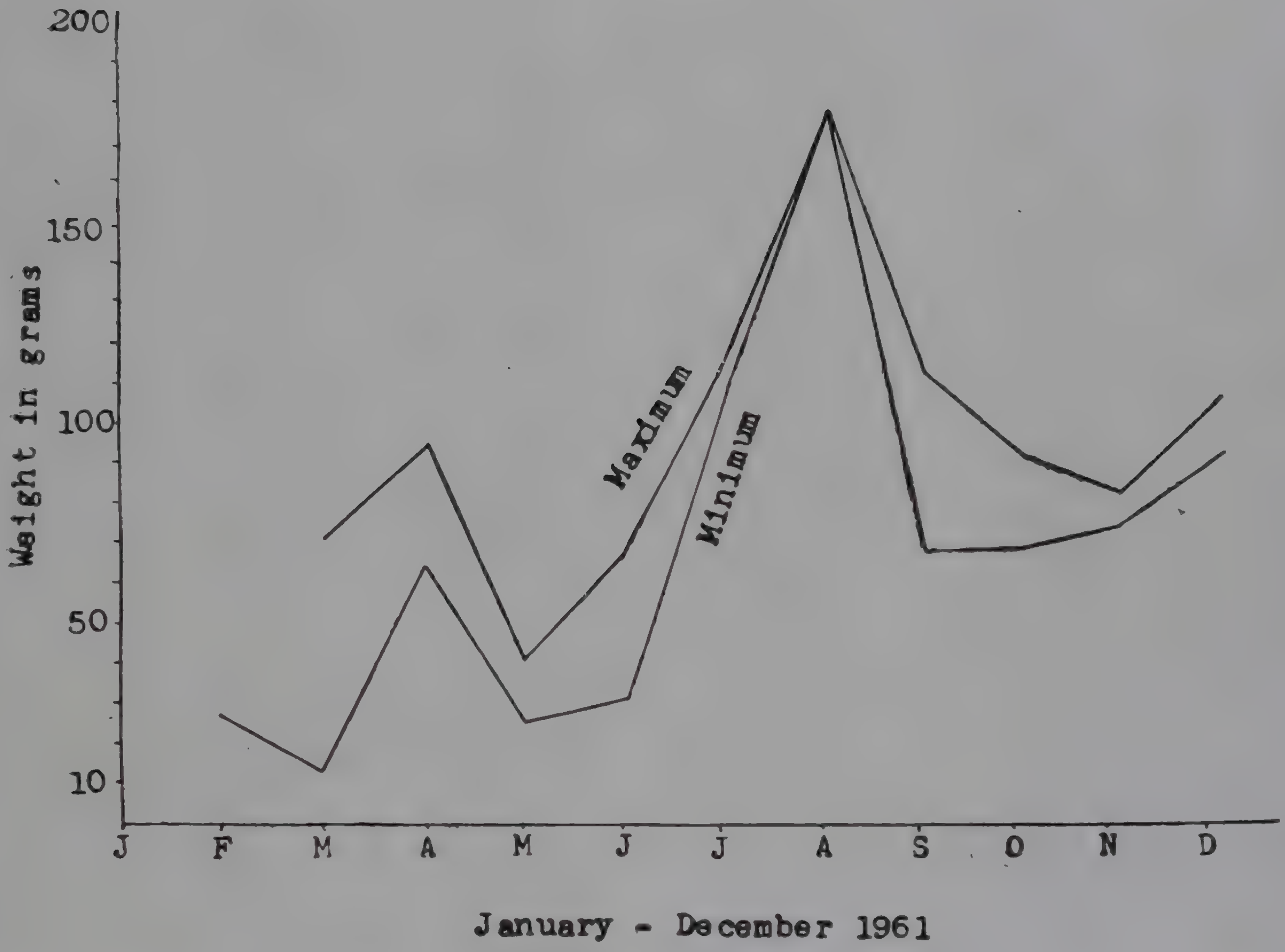
GRAPH 6.—GROWTH OF PENAEUS CARINATUS (FEMALE) IN WEIGHT IN POND S1 IN 1961.



GRAPH 7—GROWTH OF PENAEUS CARINATUS (MALE) IN LENGTH IN POND S1 IN 1961.



GRAPH 8—GROWTH OF PENAEUS CARINATUS (MALE) IN WEIGHT IN POND S1 IN 1961.



ON THE LOBSTER FISHERY TREND AND CONSERVANCY MEASURES IN KANYAKUMARI DISTRICT, MADRAS STATE

By

P. I. CHACKO, R. SRINIVASAN and R. ANANTANARAYANAN.

I. *Introduction.*

Lobsters form a fishery of commercial importance in the south-west Coast of India, particularly in Kanyakumari District of Madras State. The fishery of Kanyakumari District extends from Enayam to Leepuram. Though the availability of lobsters in this coastal belt was known for some time, organized exploitation of the fishery started only from 1956-57. The study of this fishery was also taken up from 1957 by Marine Biological Station at Cape Comorin with a view to follow the trend of fishery and to chalk out a proper and judicious management programme. A preliminary report on the lobster fishing of Kanyakumari district detailing the fishing seasons, fishing methods, total landings and catch composition, etc., during the years 1957-60 has already been published by Ramanandhan and Chacko (1962). The observations made during the nine-year period from 1957 to 1966, with reference to the trends noticed in the fishery and the conservancy measures that may be necessary to protect it are briefly discussed in the present communication.

II. *Fishing Season.*

The lobster fishery in Kanyakumari district has been found to be seasonal, commencing every year by the end of November and lasting till the end of March of the next year. Weather conditions determine the actual commencement and conclusion of the fishery every year, calm and clear sea being favourable for the fishing operations. Fishing commences when the north-east wind abates to a moderate breeze and the sea becomes calm and clear; and it concludes when the sea becomes rough by the end of March when fishing operations are hampered. The peak fishery is between 1st January and 15th February every year. At Cape Comorin and on the east of it, the fishery generally commences a little later than in the places on the west and lasts till April every year.

III. *Fishing Methods.*

Balasubramanian *et al* (1960), Miyamoto and Shariff (1962) and Ramanandhan and Chacko *(loc. cit)* have already described in detail the existing methods of lobster fishing. The common gear used are:—

1. Baited lines with anchor hooks (*Nankooram*).
2. Basket traps (*Koodu*).
3. Line and Scoop Net (*Kuntham)* and
4. Gill Nets.

The nets are found to be the most efficient, traps coming second, anchor hooks ranking third and 'Kuntham' the last.

Small catamarams manned by two to three fishermen form the usual craft for lobster fishing. Mechanised boats with bottoms-set nets are also used in lobster fishing from 1958-59. The fishing operations are usually done in seven to ten fathoms depth at a distance of 2·50 to 8·00 kilometres from the shore.

IV. *Marketing and Utilization.*

About 750 fishermen in Kanyakumari district take part in the lobster fishing every year. Their catches are daily procured by the agents of companies dealing in frozen food in Kerala State. The main purchasers are the Southern Fisheries Corporation at Muttom, Cochin Company at Manavalakurichi, Kerala Food Packers, Palluruthi and International Fisheries Corporation, Cochin. The quick frozen lobster tails are exported to U.S.A. and Canada and earn a good foreign exchange.

The price per lobster received by the fishermen vary from year to year, during the course of the season and also according to the tackle used in fishing. Lobsters caught in hooks fetch low prices because they get injured in the process of capture and do not stand transport well. Trapped lobsters are generally given better prices since they feed well on the abundant baits in the traps and are healthy and active and stand transport very well.

The range of prices fetched by the lobsters during the different years is given below. It will be seen that the demand for as well as the price of lobsters has been on the increase year after year.

Year. (1)	*Price.* (2)
1957–58	28 P.
1958–59	37 to 41 P.
1959–60	44 to 56 P.
1960–61	50 to 62 P.
1961–62	50 to 62 P.
1962–63	62 to 75 P.
1963–64	62 to 80 P.
1964–65	65 to 90 P.
1965–66	100 to 150 P.

The fishery is more or less solely constituted by the species *Pauulirus dasypus* (Latreilla). However five more species of Panulirus have also been met with; but they are comparatively rare. They are *P. interruptus* (Randall), *P. penicillatus* (*Linner*). *P. ornatus* (Fabricius), *P. polyphagus* and *P. versicolor* (Letreilla).

The estimated total annual catches of lobsters in Kanyakumari district during the period of study are as follows:—

Year. (1)	*Estimated total number of annual catches of lobsters.* (2)
1956–57	800,000
1957–58	500,000
1958–59	600,000
1959–60	300 000
1960–61	400,000
1961–62	320,000
1962–63	250,000
1963–64	200,000
1964–65	527,000
1965–66	525,400

The estimates given above are based both on the data gathered from the companies purchasing the lobsters and from the figures of daily landings at the various centres. It will be seen from the estimates given above that the annual catch of lobsters had shown a steep decline from 1956-57 to 1963-64 and seems to have revived again during 1964-65 and 1965-66. The slight increase in catch during 1958-59 and the higher catches during recent years may be due to intensive fishing spurred by the offer of better prices. The progressive decline in the fishery year after year despite better prices may be due to overfishing during the earlier years and the continuance of large-scale fishing of both mature lobsters in stages of breeding and of immature lobsters.

The sex composition of the lobster catches during the nine year period 1957-66 is shown in Table I. The percentages of male lobsters, adult males, immature males, female lobsters, adult females, berried females, females with sperm packets, females without berry or sperm packets, and immature females in the total number of lobsters examined each year are also worked out and shown in Table I. The sex composition of the different size groups of lobsters year-war during the nine year period is shown in Tables II (1 to 9). Table III shows the variations in the composition of size groups (Carapace length). during 1957 to 1966. A scrutiny of these tables reveals the following:—

1. There had been a steady decline in the annual lobster landings in Kanyakumari district, despite increase in demand and increase in the prices offered for the lobsters. As against an estimated catch of 800,000 lobsters in 1956-57, the estimated landings in 1963-64 were only 200,000. The slight increase in catch during 1958-59 and the relatively higher catches recorded during the recent years 1964-65 and 1965-66 may be due to intensive fishing spurred by the lure of better prices.

2. Though lobsters of 4 cm. to 13 cm. carapace length were caught during the past ten years, the predominant size groups every year were 5 cms. to 8 cms. in carapace length only.

3. Lobsters above 10 cm. of carapace length were generally rare, and if caught, were found to be mostly males only. Females of 10 cm. to 12 cm. carapace length were caught in 1958-59, 1961-62 and 1964-65 only during the nine year period.

4. In the commercial catches of lobsters, the sex ratio was found to be approximately 1 : 1.

5. From 4 cm. group to 6 cm. group the females dominated whereas from 6 cm. group onwards the predominence of males to females was noticed throughout the period. After 6 cm. group only very little percentage of females was caught. After 8 cm. group usually no females were caught.

6. Both male and female lobsters below 6 cm. carapace length were generally found to be immature.

7. A very high percentage of the lobsters caught was immature and below 6 cm. carapace length, as detailed below ;—

1957–58	10·94
1958–59	41·10
1959–60	24·67
1960–61	7·71
1961–62	7·34
1962–63	35·56
1963–64	32·21
1964–65	34·01
and 1965–66	33·64

8. Nearly 40 to 45 per cent of the total catches were found to be berried lobsters and immature ones.

9. More than 75 per cent of the berried females every year were found to be of the groups of 5 cm. to 8 cm. carapace length.

10. Maximum number of berried lobsters were noticed in the month of January in almost all the seasons. Therefore spawning should have occurred two to three months earlier than this period.

11. Percentage of berried lobsters calculated in random check made in different fishing centres during the peak season was 23 per cent.

12. Percentage of undersized lobsters in random check made in different fishing centres was 15 to 16 per cent during the peak season.

13. Smallest female with berry was noticed in the year 1962-63 and 1964-65, the carapace length being 4·2 cm.

14. Each berried lobster roughly carried about 200,000 to 500,000 eggs.

15. Generally bigger lobsters were caught by nets.

16. Lobsters caught around Cape Comorin were comparatively smaller and blackish, probably due to the environmental conditions. Lobsters caught at Colachel area were greenish. Lobsters caught at Enayam and Enayam puthanthurai were bigger in size, probably due to the favourable environmental conditions and the availability of more food.

17. There is almost a direct proportional relationship between the length and weight of the lobsters. The weight of individual lobsters in the commercial catches ranged from 40 to 1,920 grams.

VI. *Discussion on lobster conservation measures.*

The observations detailed above on the lobster fishery trend in Kanyakumari district during the nine year period, 1957 to 1966, show that a major portion (40 per cent to 45 per cent) is constituted by immature and berried individuals. From the year 1962-63 onwards a high percentage of the lobster catches (32·21 to 35.56 per cent), was found immature and below 6 cm. carapace length indicating indiscriminate fishing indulged by the fishermen lured by the offer of high prices. There also had been a steady dwindling in the number of lobsters landed each year, from 800,000 in 1956-57 to 200,000 in 1963-64. The higher figures of 527,000 lobsters in 1964-65 and 525,400 in 1965-66 probably indicate a temporary upward trend in the fishery or they may also be due to increased catching efforts spurred by the offer of higher prices. It is relevent to point out here that the lobster fishery is becoming increasingly popular in the district due to greater demand for lobster from the processing factories in Kerala State and the higher prices paid for the lobsters. Naturally more and more fishermen are taking to this fishery and the catching efforts are on the increase year after year. This increasing demand of lobsters by the processing industry coupled with the natural increase in catching efforts may sooner or later cause a depletion of the basic stock of lobsters off the Kanyakumari district coast especially since these lobsters are not migratory and as such have very little scope for repopulation by migration from other areas. It may be argued that the phyllosoma larve is well represented in plankton and its distribution is facilitated by the long larval life extending to several months. Lobsters having good fecundity, the success or failure of lobster fishery is largely dependant on the availability or otherwise of suitable rocky larval settlement areas and so there is not much risk of over-exploitation of the lobster fishery. Taking this argument into account and even if one may hold the view that the lobster fishery is a fluctuating one and that sufficient data are not yet available to assume a depletion, one will have to agree that the berried females and the juveniles should be saved from indiscriminate fishing.

In almost all lobster fishing countries one or other of the following conservation measures are adopted to conserve the stocks :

(i) Observation of a " closed season " for fishing ;

(ii) Prohibition of fishing immature and berried lobsters ; and

(iii) Prohibition of injurious gear.

In Canada, gear is restricted by law to the conventional lobster trap and fishing is also restricted to two to seven months intended in part to ensure that lobsters are landed in good condition. There have also been regulations specifying the minimum sizes of lobsters that may be landed with a view to maintain or increase landing by allowing more young lobsters to grow to more valuable sizes and to reach maturity. Since growth rate, sizes at maturity, and the sizes of lobsters vary considerably along the coast, different size limits have been adopted. Carapace size limits of two and half inches, two and three-fourth inches, three inches and three and three-sixteenth inches are now in effect in different areas. (MCleese and Wilder, 1964). In Fiorida, the closed season is March to July and it is illegal to take lobsters less than nine inches long and about one pound in weight (Tressler and Jones Mc (W, Lemon, 1931). The possibilities of introducing these conservancy measures for the lobster fishery of Kanyakumari district are discussed below:—

(i) *Closed season.*—In Kanyakumari district lobster fishing is suspended every year from April to October due to unfavourable weather conditions. But this may not serve as a closed season since the lobsters are found to breed only from November to March which is also the fishing season for lobsters in the area. The peak breeding activity is in November and December when nearly 70 per cent of the females are found berried. The protection of berried females is therefore possible only if the entire season is closed for lobster fishing. But in view of the very long period during which the lobsters are berried compared with the short lobster fishing season of only five months in a year, the observance of closed season does not seem possible. However detailed investigations may have to be conducted on the actual breeding intensity of lobsters so that in case the breeding intensity is found to be maximum only during a narrow period of one or two months only during the fishing season, this short period may be declared as closed season.

(ii) *Prohibition of fishing immature lobsters and berried individuals.*—Investigations conducted have shown that there is indiscriminate fishing of immature and berried lobsters, which account for nearly 40 to 45 per cent of the total catches. The immature lobsters measuring below 6 cm. in carapace length form as high as 32.21 to 35.56 per cent of the total catches of lobsters in recent years. It is felt a suitable restriction in the landings has to be enforced to prevent such large scale destruction of immature and berried lobsters. This can be achieved by imposing size regulation on the lobsters caught and by adopting measures to return the undersized and berried ones back into the sea alive.

Lobsters of less than 6 cm. carapace length and berried individuals should not be landed by any method of fishing. If they are accidentally caught in a gear, they should be released into the sea alive immediately. Necessary legislation will have to be enacted covering areas in Madras and Kerala States. According to this legislation possession of lobsters either alive or dead in the prohibited sizes and groups in the areas covered by the legislation, any individual, marketing agency or processing factory should be considered as unlawful and punishable. State Fishery officials of the rank of an Assistant Inspector of Fisheries and above should be empowered to conduct random inspection of the gear at site and markets at regular intervals and confiscate the catches comprising of lobsters of prohibited sizes and groups and also take appropriate action necessary to punish the individuals concerned for violation of the conservancy measures. Similarly the Inspectors under the Quality Control Scheme could also be empowered by the legislation to inspect the processing factories at regular intervals. Importance and the need for the above measures should be given wide publicity and by issuing time-to-time warning notices in the areas of operation. The fisherfolk should also be educated on the significance of the lobster fishery conservation through pamphlets, posters, lectures and film shows.

It will be interesting to point out here that in some countries like Britain where they had banned the fishing of berried lobsters some rethinking has been done and the ban has since been lifted as a result of further studies. Canadian research workers have failed to find any factual basis for protecting egg-bearing females and consequently have come to the conclusion that nothing is to be gained by protecting the berried lobsters. As far back as 1913 the French authorities accepted the view that the administrative difficulties of enforcing legislation protecting the berried lobsters were too great and therefore repealed the existing decree (Thomas, 1966). The same scientist while discussing the heavy exploitation of lobsters on the east coast of Britain however recommends that under circumstances of very heavy fishing, any method of reducing the numbers of young lobsters caught will eventually result in a higher annual catch from the fleet as a whole, and that a return of berried lobsters to the sea or an increase in the minimum size limit or less intensive fishing would all afford protection of the stocks. Hence the question of banning the fishing of berried lobsters may have to be judged from the merits and need of each case and not merely based on general observations and experiences elsewhere.

(iii) *Prohibition of injurious gear.*—In the method of baited lines with anchor hooks the lobsters are landed injured and hence are not suitable for processing and if by chance they are undersized or berried, because of the injury there will be no point in releasing them back into the sea. Hence this method of fishing should be prohibited under the conservancy legislation.

In the other three methods, the lobsters are taken alive and if handled carefully there is no likelihood of any injury to the lobster and all these methods may be allowed subject of course to a system of licensing for better control of the fishery. The method of operation of the basket traps is very difficult. A fisherman usually dives down to set the traps and on the following day he has to dive again for their recovery. On an average about ten traps are set by a single catemaran unit of two fishermen. Because of the difficulty in operation, there is already a self-imposed restriction in the number of fishermen engaged and the number of traps operated. Line and scoop' net is practised only by a few fishermen engaged in that method and is not very popular due to its relative inefficiency. Gill nets at present are very sparingly used in lobster fishing and only in a few centres. However, since they are simple in operation and the output is also more, they are likely to become popular when the method of fishing with anchor hooks is prohibited. To prevent immature or small lobsters being landed, the mesh size of the nets should be prescribed as 15 cm. stretched measure (7·5 cm. bar).

Refernces.

1 Balasubramanian, R. Satyanarayana, M. V. V. and Sadanandan, K. A. (1960). “A preliminary account of the experimental Rock-lobsters fishing conducted along the South-West Coast of India with bottom-set gills nets ” *Indian Journal of Fisheries*, 7 (1), 407—422.

2 Melease, D. W. and Wilder, D. G. (1964). “ Lobster Storage and shipment ” Bulletin No. 147, The Fisheries Research Board of Canada.

3 Myamoto, H and Sharifi, A. T. (1962) .. .. “ Lobster fishery off the South-West Coast of India. Anchor, Hook and Trap Fisheries ” *Indian Journal of Fisheries*, 9 (1), 252–268.

4 Ramanadhan, R. and Chacko, P. I. (1962) .. “ A preliminary Report on the lobster fishery of Kanyakumari district coast”. *Fisheries Station Reports, and year book, Department of Fisheries Madras April*, 1957—*March* 1958, 86—93.

5 Thomas H. J. (1966) .. .. “ Berried Lobsters: World Fishing 159, 52—55.

6 Tressler, Donald, K. and Jones Mc. W. Lemon, H.S. (1931). “Marine Products of Cemmerce, *Reinhold Publishing Corporation, New York*.

TABLE I.

Showing the Sex composition of lobster catches in Kanyakumari District during the year 1957 58.

Male Lobsters. (1)	*Male adults.* (2)	*Male immature and maturing.* (3)	*Lobsters. Female.* (4)	*Female adults.* (5)	*Female berried.* (6)	*Female with sperm packet.* (7)	*Female without berry or sperm packet.* (8)	*Female lobster immature and maturing.* (9)
1957–58—								
(*a*) 40·23	40·23	Nil.	59·77	52·30	28·73	13·80	17·24	7·47
(*b*)	100	Nil.	..	87·5	48·08	23·07	28·8	12·5
1958–59—								
(*a*) 44·6	32·70	11·90	55·4	42·70	20·50	7·50	14·7	12·7
(*b*)	72·31	26·67	..	77·07	37·0	13·53	26·53	22·94
1959–60—								
(*a*) 54·00	52·66	1·33	46·0	45·33	21·00	17·00	7·33	0·66
(*b*)	97·53	2·47	..	98·55	45·65	37·00	15·94	1·45
1960–61—								
(*a*) 60·4	55·62	0·82	39·56	37·19	21·26	21·76	10·90	2·37
(*b*)	98·63	1·37	..	94·06	53·14	54·39	27·26	5·94
1961–62—								
(*a*) 59·07	57·30	1·77	40·43	38·36	17·53	5·87	15·30	2·57
(*b*)	97·00	3·00	..	93·73	42·59	14·33	37·38	6·27
1962–63—								
(*a*) 52·87	50·70	2·20	47·13	45·13	6·33	7·50	34·87	2·00
(*b*)	96·46	3·54	..	95·77	13·40	15·90	51·30	4·23
1963–64—								
(*a*) 54·55	54·30	0·15	45·55	45·30	3·55	11·28	13·86	0·25
(*b*)	99·75	0·25	..	99·43	7·79	24·88	37·01	0·57
1964–65—								
(*a*) 58·36	57·56	0·8	41·64	40·70	2·65	7·14	8·36	0·94
(*b*)	98·63	1·37	..	97·66	6·35	17·14	20·90	2·34
1965–66—								
(*a*) 52·20	51·53	0·67	47·80	47·13	0·98	10·04	15·17	0·67
(*b*)	98·74	1·26	..	98·63	2·05	21·00	31·74	1·37

NOTE—(*a*) Percentage in the total examined.
(*b*) Percentage in the total number of particular sex.

TABLE II.

(1) *Showing the sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari District during the year* 1957–58.

Size group.	*Percentage of size group in the total. examined.*	*Percentage of males.*		*Percentage of females.*			
		Adult.	*Immature.*	*Berried.*	*With sperm packet.*	*Other adults.*	*Immature.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4 cm.	2·87	Nil.	Nil.	Nil.	Nil.	Nil.	100·00
5 cm.	8·05	14·29	Nil.	14·29	7·14	7·14	57·14
6 cm.	18·97	42·42	Nil.	30·30	15·15	12·12	Nil.
7 cm.	40·80	30·98	Nil.	39·44	18·31	11·27	Nil.
8 cm.	21·84	50·00	Nil.	26·32	3·16	10·53	Nil.
9 cm.	5·75	100·00	Nil.	Nil.	Nil.	Nil.	Nil.
10 cm.	1·72	100·00	Nil.	Nil.	Nil.	Nil.	Nil.

TABLE II—*con't.*

(2) *Showing sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari district during the year 1958–59.*

Size group. (1)	Percentage of size group in the total examined. (2)	Percentage of males. Adult. (3)	Percentage of males. Immature. (4)	Percentage of females. Berried. (5)	Percentage of females. With sperm packet. (6)	Percentage of females. Other adults. (7)	Percentage of females. Immatur (8)
4 cm.	7·60	Nil.	47·37	Nil.	Nil.	Nil.	52·63
5 cm.	33·50	26·27	24·48	2·98	1·79	18·81	25·67
6 cm.	18·40	44·57	0·54	26·09	9·24	19·56	Nil.
7 cm.	21·90	31·51	Nil.	42·92	11·42	14·10	,,
8 cm.	10·70	37·38	,,	32·71	15·88	14·02	,,
9 cm.	4·50	55·56	,,	22·22	17·78	4·44	,,
10 cm.	1·50	33·30	,,	46·70	20·00	Nil.	,,
11 cm.	0·90	88·89	,,	11·11	Nil.	,,	,,
12 cm.	0·50	100·00	,,	Nil.	,,	,,	,,
13 cm.	0·40	100·00	,,	,,	,,	,,	,,

(3) *Showing sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari district during the year 1959–60.*

Size groups. (1)	Percentage of size group in the total examined. (2)	Percentage of males. Adult. (3)	Percentage of males. Immature. (4)	Percentage of females. Berried. (5)	Percentage of females. With sperm packet. (6)	Percentage of females. Other adults. (7)	Percentage of females. Immatu (8)
4 cm.	3·00	22·22	11·11	11·11	22·22	22·22	11·11
5 cm.	21·67	21·54	3·08	43·08	15·38	15·38	1·53
6 cm.	42·33	51·18	Nil.	18·97	24·45	5·51	Nil.
7 cm.	21·66	72·31	,,	15·38	10·77	1·54	,,
8 cm.	7·67	91·31	,,	Nil.	4·35	4·35	,,
9 cm.	2·33	100·00	,,	,,	Nil.	Nil.	,,
10 cm.	1·33	75·00	,,	,,	,,	,,	,,

(4). *Showing sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari district during 1960–61.*

Size groups. (1)	Percentage of size group in the total examined. (2)	Percentage of males. Adult. (3)	Percentage of males. Immature. (4)	Percentage of females. Berried. (5)	Percentage of females. With sperm packet. (6)	Percentage of females. Other adults. (7)	Percentage of females. Immat (8)
5 cm.	7·71	39·65	10·06	Nil.	1·18	18·34	30·7
6 cm.	22·95	51·09	0·19	18·09	7·16	23·46	Nil.
7 cm.	36·86	55·95	Nil.	30·69	8·42	4·94	,,
8 cm.	24·36	68·33	,,	21·34	4·21	6·11	,,
9 cm.	6·20	88·89	,,	5·93	0·74	1·44	,,
10 cm.	1·87	100·00	,,	Nil.	Nil.	Nil.	,,
11 cm.	0·046	100·00	,,	,,	,,	,,	,,
12 cm.	0·046	100·00	,,	,,	,,	,,	,,

TABLE II—*cont.*

(5) *Showing sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari district during the year 1961–62.*

Size groups.	*Percentage of size group in the total examined.*	*Percentage of males.*		*Percentage of females.*			
		Adult.	*Immature.*	*Berried.*	*With sperm packet.*	*Other adults.*	*Immature.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4 cm.	0·57	Nil.	41·2	Nil.	Nil.	Nil.	58·8
5 cm.	6·77	18·23	21·18	27·09	3·45	,,	30·05
6 cm.	23·43	46·37	0·28	47·38	5·26	,,	0·71
7 cm.	39·97	58·38	Nil.	35·36	6·26	,,	Nil.
8 cm.	21·00	69·52	,,	25·39	5·08	,,	,,
9 cm.	6·87	87·38	,,	11·65	0·97	,,	,,
10 cm.	1·03	90·32	,,	9·68	Nil,	,,	,,
11 cm.	0·13	50·00	,,	50·00	,,	,,	,,
12 cm.	0·23	47·14	,,	28·57	14·29	,,	,,

(6) *Showing the sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari district during the year 1962–63.*

Size groups.	*Percentage of size group in the total examined.*	*Percentage of males.*		*Percentage of females.*			
		Adult.	*Immature.*	*Berried.*	*With sperm packet.*	*Other adults.*	*Immature.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4 cm.	14·63	34·85	15·03	0·68	1·82	33·94	13·67
5 cm.	26·93	43·32	Nil.	18·81	10·77	27·10	Nil.
6 cm.	36·33	52·29	,,	20·55	8·89	18·26	,,
7 cm.	17·23	67·12	,,	13·73	5·22	13·92	,,
8 cm.	4·87	68·49	,,	8·90	4·11	18·49	,,

(7) *Showing sex composition of the different size groups (carapace length) of lobster fishery in Kanyakumari district during the year 1963–64.*

Size groups.	*Percentage of size group in the total examined.*	*Percentage of males.*		*Percentage of females.*			
		Adult.	*Immature.*	*Berried.*	*With sperm packet.*	*Other adults.*	*Immature.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
4 cm.	7·64	44·60	1·88	1·41	0·94	47·89	3·28
5 cm.	24·57	47·74	Nil.	22·77	11·24	18·25	Nil.
6 cm.	37·45	54·11	,,	20·88	15·52	9·58	,,
7 cm.	20·33	55·38	,,	26·81	9·52	8·29	,,
8 cm.	6·86	69·59	,,	23·04	6·81	1·57	,,
9 cm.	3·02	92·86	,,	2·38	2·38	2·38	,,
10 cm.	0·11	100·00	,	Nil.	Nil.	Nil.	,,
11 cm.	0·04	100·00	,,	,,	,,	,,	,,
12 cm.	9·09	27·97	,,	44·06	3·83	14·94	,,

TABLE II—*cont.*

(8) *Showing sex composition of the different size groups (Carapace length) of lobster fishery on Kanyakumari district during the year 1964–65.*

Size group.	*Percentage of size group in the total examined.*	*Percentage of males.*		*Percentage of females.*				
		Adults.	*Immature.*	*Adults.*	*Berried.*	*With berry and sperm packet.*	*With sperm packet.*	*Immatu*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9
3 cm.	0·10	..	100·00	..	..	..	..	
4 cm.	9·78	48·40	7·12	33·81	0·17	0·36	..	9·
5 cm.	24·13	57·29	..	32·18	1·88	4·18	3·03	
6 cm.	30·09	62·18	..	17·33	2·11	7·03	11·36	
7 cm.	24·55	62·98	..	9·50	4·54	14·75	7·24	
8 cm.	9·09	27·97	..	44·06	3·83	14·94	9·20	
9 cm.	1·18	81·48	..	..	..	9·26	9·26	
10 cm.	0·12	100·00	..	..	..	..	..	
11 cm.	0·28	75·00	..	..	12·5	12·5	..	
12 cm.	0·03	..	..	..	..	100·00	..	

(9) *Showing the sex composition of the different size groups (Carapace length) of lobster fishery in Kanyakumari district during the year 1965–66.*

Size group.	*Percentage of size group in the total examined.*	*Percentage of males.*		*Percentage of females.*				
		Adults.	*Immature.*	*Adults.*	*Berried.*	*With berry and sperm packet.*	*With sperm packet.*	*Immature.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
4 cm.	11·03	44·55	5·94	43·57	..	..	..	5·94
5 cm.	22·61	40·09	..	35·26	0·96	13·53	9·66	..
6 cm.	36·03	47·27	..	13·94	1·82	22·42	14·55	..
7 cm.	20·31	69·35	..	8·60	0·54	12·90	8·60	..
8 cm.	8·52	66·67	..	12·82	..	10·26	10·26	..
9 cm.	1·09	50·00	..	10·00	..	40·00	..	..
10 cm.	0·33	33·33	..	33·33	..	33·33	..	..
11 cm.	..	..	..	..	..	..	..	..
12 cm.	0·11	100·00	..	..	..	..	..	..

TABLE III.

Showing variations in per cent composition of size groups (Carapace length) of lobster of Kanyakumari district during the period 1957—66.

Size groups. (1)	1957–58. (2)	1958–59. (3)	1959–60. (4)	1960–61. (5)	1961–62. (6)	1962–63. (7)	1963–64. (8)	1964–65. (9)	1965–66. (10)
3 cm.	..	..	..	..	..	..	..	0·10	..
4 cm.	2·87	7·60	3·00	Nil.	0·57	14·63	7·54	9·78	11·03
5 cm.	8·05	33·50	21·67	7·71	6·77	20·93	24·57	24·13	22·61
6 cm.	18·97	18·40	42·33	22·95	23·43	36·33	37·45	30·09	36·03
7 cm.	40·80	21·90	21·66	36·86	39·97	17·23	20·33	24·55	20·31
8 cm.	21·84	10·70	7·67	24·36	21·00	4·87	6·86	9·09	8·52
9 cm.	5·75	4·50	2·33	6·20	6·87	Nil.	3·02	1·18	1·09
10 cm.	1·72	1·50	1·33	1·87	1·03	Nil.	0·11	0·42	0·33
11 cm.	Nil.	0·90	Nil.	0·046	0·13	Nil.	0·04	0·28	Nil.
12 cm.	Nil.	0·50	Nil.	0·046	0·23	Nil.	Nil.	0·03	0·11
13 cm.	Nil.	0·40	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.

EFFECT OF ORGANIC AND INORGANIC MANURES ON PLANKTON PRODUCTION AND DISSOLVED OXYGEN CONTENT OF FISH NURSERIES.

By A. Sreenivasan, R. Soundararaj and T. Franklin.

HYDROBIOLOGICAL RESEARCH STATION, MADRAS-10.

Introduction.

Fish cultural practices are gaining momentum in our State. Consequently the demand for fish seeds is increasing. Fish spawn or fry cannot be introduced directly into stocking ponds or lakes as the tender fry may not be able to fend for themselves in association with predatory organisms and so the hatchlings have to be reared first in nurseries till they attain the 'finger ling' size, i.e., over 4·0 cm. Fish nurseries are small Kitcha pits or masonry or stone built ponds with a depth of 1 m.-1·5 m. These nurseries may not have adequate quantities of zooplankton, which form the essential food for the hatchlings and small fry. Hence these nurseries have to be suitably manured prior to the introduction of hatchlings.

Generally the nurseries are manured with cow-dung at the rate of 10,000 to 1,00,000 lb. per acre (Alikunhi 1957). Cow-dung being an organic manure, it may deplete the dissolved oxygen content of water due to putriefaction. Low dissolved oxygen level will cause asphyxiation and mortality or result in poor feeding by the fish. Hence it is desirable to find out the optimum level of cow-dung application which may not deplete the dissolved oxygen in the ponds.

The effect of cow-dung and a combination of cow-dung and inorganic fertilisers on the dissolved oxygen of water and on plankton production, was studied and the results are presented in this paper.

Four sets of experiments were conducted using (i) organic manure alone and, (ii) a combination of organic manure and inorganic fertilizers.

Material and Method.

The experiments were carried out in cement tanks of dimension 6 metres by 3 metres by 1·5 metres. All the 'tanks' were filled with red soil to a depth of 15 cm. (6 inches), filled with water to a depth of 1·0m. and, then treated with manure or fertilisers. One of the tanks was kept as control. Urea, Superphosphate and Ammonium phosphate were the inorganic fertilisers used and, cow-dung was the organic manure. Water samples were collected on alternate days and analysed according to standard methods. (APHA 1946). Plankton samples were collected by filtering 10 l. of water through bolting silk plankton net having 60 meshes/cm. The plankton samples were analysed qualitatively and quantitatively.

Results.

Series I.—The fertilisers and their rate of application are furnished in Table I.

TABLE I.

Tank number.	*Fertilisers.*	*Quality per acre.*
(1)	(2)	(3)
I ..	Fresh Cow-dung ..	10,000 lb.
II ..	Fresh Cow-dung plus Urea.	10,000 lb. plus 100lb.
III ..	Control	.. .. ..

In Tank I, Oxygen depletion occurred twice within 30 days. one during the first and the other during the last week of the month, whereas in tank II low dissolved oxygen level was noticed only during the first week. (*See* Fig. 1).

Tank II developed plankton bloom earlier than the other two tanks. The volume was high 1·1 cc. and the constancy in the volume of plankton also was maintained, for a longer period. In Tank I there was wide fluctuations in the quantity of plankton and the maximum volume of plankton was only 0·6 cc. *(See* Fig. 1.P). The genera of zoo and phytoplankters occurring in the three tanks are given in Table P.I. In tank I cyclops and *Microcystis* were the dominant zoo and phytoplankters respectively. In Tank II *Cyclops, Daphnia, Eubranchipus* and *Brachionus* were the dominant Zoo plankters. *Oscillatoria, Microcystis, Anabaena, Tetrapedia* and *Navicula* dominated among phytoplankters. *Anabaena* occurred in swarms. Similar case was recorded by Matida (1955) in "Onna Lake'.

Series II.—The same fertilisers at the same rate as in series I were applied. Identical results were obtained. Low dissolved oxygen was recorded twice during the month in Tank I. Oxygen depletion never occurred in Tank II. (*See* Fig. 2). Higher plankton production was noticed in Tank II (1·6 cc). As in the first series of experiment there was fluctuation in the volume of plankton in Tank I and 0·8 cc. was the maximum volume (*See* Fig. 2 p). The same species of plankton as in sereis I were recorded in this series also.

Series III.—The details of the fertilisers and the rate of application are furnished in Table II.

As in the previous sets of experiment in this also oxygen depletion occurred twice in Tank I in a period of 30 days. The dissolved oxygen was always more than 4 PPM in Tank II and was fairly high in Tanks III and IV (*See* Fig. 3).

TABLE II.

Tank number.	*Fertilisers.*	*Quantity per acre.*
(1)	(2)	(3)
I ..	Fresh Cow-dung ..	10,000 lb.
II ..	Fresh Cow-dung plus urea.	10,000 lb. plus 100 lb.
III ..	Fresh Cow-dung plus Superphosphate.	10,000 lb. plus 100 lb.
IV ..	Fresh Cow-dung plus Am. Phosphate.	10,000 lb. plus 100 lb.
V ..	Control	..

It is quite interesting to observe that Tank II produced the maximum volume of plankton (1·9 cc.) as in the previous sets of experiment and Tank I was second in plankton production (1·4 cc). It was comparatively low in Tank III (0·7 cc.) and in Tank IV it was fairly high and it ranked third in plankton production (1·0 cc.). (*See* Fig. 3.P.). The genera of plankters occuring in the tanks are given in Table P. III.

Series IV.—The amounts and fertilisers applied are tabulated in Table III.

TABLE III.

Tank number.	*Fertilisers.*	*Quantity per acre.*
(1)	(2)	(3)
I ..	Fresh Cow-dung ..	10,000 lb.
II ..	Fresh Cow-dung plus Urea.	10,000 lb. plus 50 lb.
III ..	Fresh Cow-dung plus Superphosphate.	10,000 lb plus 50 lb.
IV ..	Fresh Cow-dung plus Am. Phosphate.	10,000 lb. plus 50 lb.
V ..	Control	..

In this set of experiment unlike the previous sets, the chemical fertilisers are reduced to half the previous rate. Cow-dung was applied at the same rate as in the case of previous experiments.

In all the tanks except the control there was a decrease in the dissolved oxygen content and in tank IV it was only just above 4 PPM even after 15 days, as it was in series III (*See* Fig. 4). In this series also Tank II developed high plankton content. Tank I ranked second, 0·3 cc. In other tanks the plankton production was always less than 0·1 cc. (*See* Fig. 4.P.). The duration of this set of experiment was only seventeen days.

It is quite evident from the analysis of the results that the rate of chemical fertilisers applied along with cow-dung had definite bearing on plankton production.

The species of plankters occuring in the tanks are given in Table P. IV.

Changes in Chemical Condition.

The chemical changes after the addition of fertilisers were studied. In cow-dung treated tank the pH ranged from 6·9 to 8·5. Low pH was found to be associated with the low dissolved oxygen content. Dissolved inorganic phosphate was detected upto a period of 20 to 25 days. But during the first five days no phosphate was recorded. In the tank treated with cow-dung and urea the pH was always high, ranging from 8·9 to 9·5. Ammonia was detected in this tank upto a period of 8 days in traces. Afterwards loss of Ammonia was recorded. The same chemical changes were recorded in the tank treated with cow-dung and Ammonium phosphate. The pH was normal, ranging from 7·5 to 8·5 in the cow-dung superphosphate treated tank. The presence of inorganic phosphate was noticed throughout the period of experiment except the last few days. During the first seven days it was 0·05 PPM. Then it slowly dwindled down to 0·01 PPM and finally disappeared. Freda Chandrasekaran and Sreenivasan (1962) recorded the disappearance of phosphate within a few days after the application of this fertilization alone. But in the present sets of experiments phosphate was detected throughout the period. This may be due to the slow releasing of inorganic phosphate by the decomposing cow-dung.

Discussion.

From the series of experiments it could be seen that cow-dung and urea combination is the best and could produce more plankton per unit volume of water and in quicker period. Unlike organic manure alone this combination does not deplete the dissolved oxygen content of water. Cow-dung releases the inorganic phosphate and actually this liberated phosphate and the urea added with the cow-dung act together. Swingle and Smith (1950) are of opinion that nitrogenous fertilisers have stimulating effect on the growth of phytoplankton. This may be true with inorganic nitrogenous fertiliser alone, but our results show that the organic cow-dung and urea combination supports the growth of both phyto and zoo plankton. This combination is recommended for fish nurseries in which hatchlings are to be raised to fry and fingerlings.

Summary.

A mixture of organic and inorganic manures are superior to organic or inorganic manure alone. The best combination for manuring nurseries is cow-dung plus urea at the rate of 10,000 lb. of cow-dung and 100 lb. urea per acre. If organic manure alone is used oxygen depletion in the water medium is inevitable but a combination of organic and inorganic fertiliser never allows the dissolved oxygen of the medium to go down to lethal level. The cow-dung, urea combination produces plankton both the types, i.e., zoo and phytoplankton ar it maintains the phytoplankton population such a proportion, that oxygen depletion neve occurrs in the water medium.

References.

1. Am. Public Health Assoc. and Am. Water Works Assoc. "Standard methods for the examination of water and sewage", 1946.

2. Alikunhi, K. H.—" Fish Culture in India ". Farm Bull No. 20 of Indian Council of Agricultural Research, New Delhi—1-144, 1957.

3. Freda Chandrasekaran, Mrs. and Sreenivasan, A. (1963)—" Preliminary studies on the use of inorganic fertilisers to increase fish production ". Madras Journ. of Fish. Vol. I.

4. Komarovsky, B (1953)—" A comparative study of phytoplankton of Several fish ponds in relation to the essential chemical constituent o Water ". Bull. Research Council, Israel Vol. 2

5. Matida, Y.—Study of farm Pond Fish Culture No. 2—" A chemical study on the effect o fertilisers to plankton production ". Bull. Fresh Water Fish. Res. Lab. 4, 1955.

6. Pringsheim, E. G. (1949)—" Pure culture of algae, their preparation and maintenance ". Cambridge Univ. Press.

7. Ruttner, F., Frey D. G. and Fry. F. E. J. 1953—" Fundamentals of Limnology."

8. Swingle, H. S., and Smith, E. V. (1950)—Management offar m fish ponds. Ala., Agri. Sta. Bull 254.

Tables showing the genera of Zoo and Phyto Plankters present in the tanks.

TABLE P-I.

Plankton.	*Tank I.*	*Tank II.*	*Tank III.*
Zoo Plankton—			
1 Cyclops	A	A	S
2 Daphnia	C	A	..
3 Nauplius	F	C	..
4 Eubranchipus	C	A	..
5 Brachionus	M	A	..
Phyto Plankton—			
6 Oscilla toria	F	A plus	..
7 Microcystis	A	A plus	..
8 Anabaena	C	A plus	..
9 Cyclotella	S	F	S
10 Spirulina	C	C	..
11 Chlorella	F	S	S
12 Tetrapedia	S	A	..
13 Navicula	R	A	R

TABLE P-II.

Plankton.	*Tank I.*	*Tank II.*	*Tank III.*
Zoo Plankton			
1 Cyclops	A	A	..
2 Daphnia	F	A	..
3 Nauplius	C	F	..
4 Eubranchipus	F	F	..
5 Brachionus	C	A	..
Phytoplankton—			
6 Oscillatoria	S	S	S
7 Microcystis	A	A plus	..
8 Anabaena	A	A plus	..
9 Cyclotella	S	F	S
10 Spirulina	C	A	..
11 Chlorella	C	F	R
12 Tetrapedia	F	A	..
13 Navicula	S	S	S

Tables showing the Genera of Zoo and Phyto Plankters present in the tanks.

TABLE P. III.

Plankton.	*Tank. I*	*Tank. II*	*Tank. III*	*Tank. IV*	*Tank. V*
Zoo Plankton—					
1. Daphnia	A	A plus.	C	F	..
2. Cyclops	F	A	F	C	..
3. Eubranchipus	C	A	F	F	..
4. Nauplius	C	C	C	F	..
5. Brachionus	F	F	C	C	..
Phytoplankton—					
6. Keratella	C	F	F	R	R
7. Cyclotella	R	C	F	F	S
8. Microcystis	F	A	F	C	..
9. Anabaena	C	A plus.	C	C	..
10. Spirulina	C	A plus.	F	C	..
31. Pediastrum	S	A	F	C	..
12. Chlorella	S	F	F	F	..
13. Navicula	R	R	R	R	..

TABLE P. IV.

Plankton.	*Tank. I*	*Tank. II*	*Tank. III*	*Tank. IV*	*Tank. V*
Zoo Plankton—					
1. Daphnia	A	C	C	F	..
2. Cyclops	F	C	F	C	..
3. Eubranchipus	F	F	F	C	..
4. Nauplius	C	C	R	F	..
5. Brachionus	F	F	F	C	..
6. Keratella	C	F	S	R	R
Phytoplankton—					
7. Cyclotella	C	F	C	A	..
8. Microcystis	F	C	A	C	..
9. Anbaena	F	A	F	F	..
10. Spirulina	C	F	F	C	S
11. Pediastrum	S	C	C	C	..
12. Chlorella	R	F	C	R	..
13. Navicula	S	S	R	S	..

A plus — Bloom. A — Abundant C — Common F— Moderate number S — Scarce.
R — Only 2 or 3 per collection.

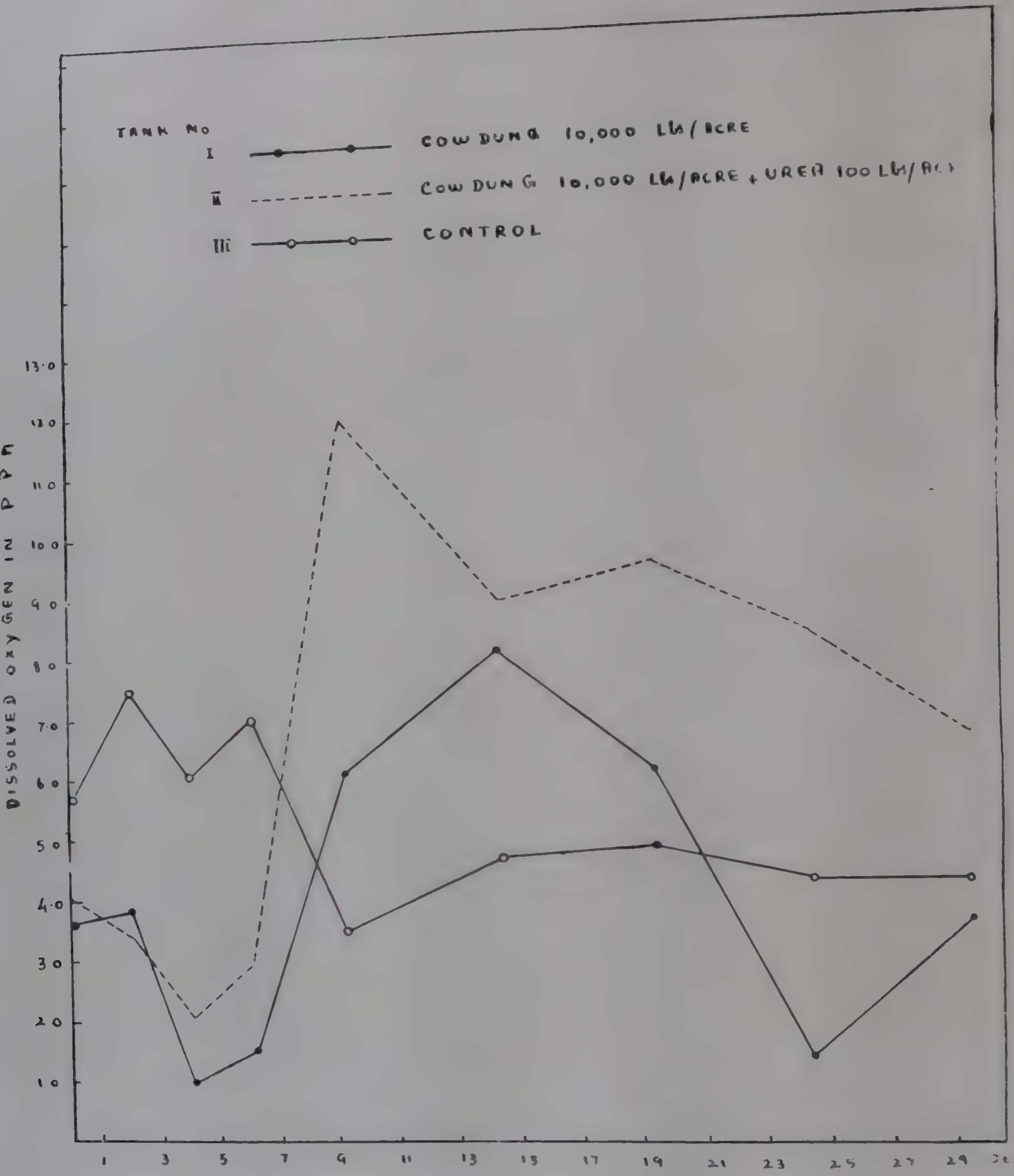


FIG. 1 Effect of cowdung and chemical fertilisers on dissolved oxygen content of water.

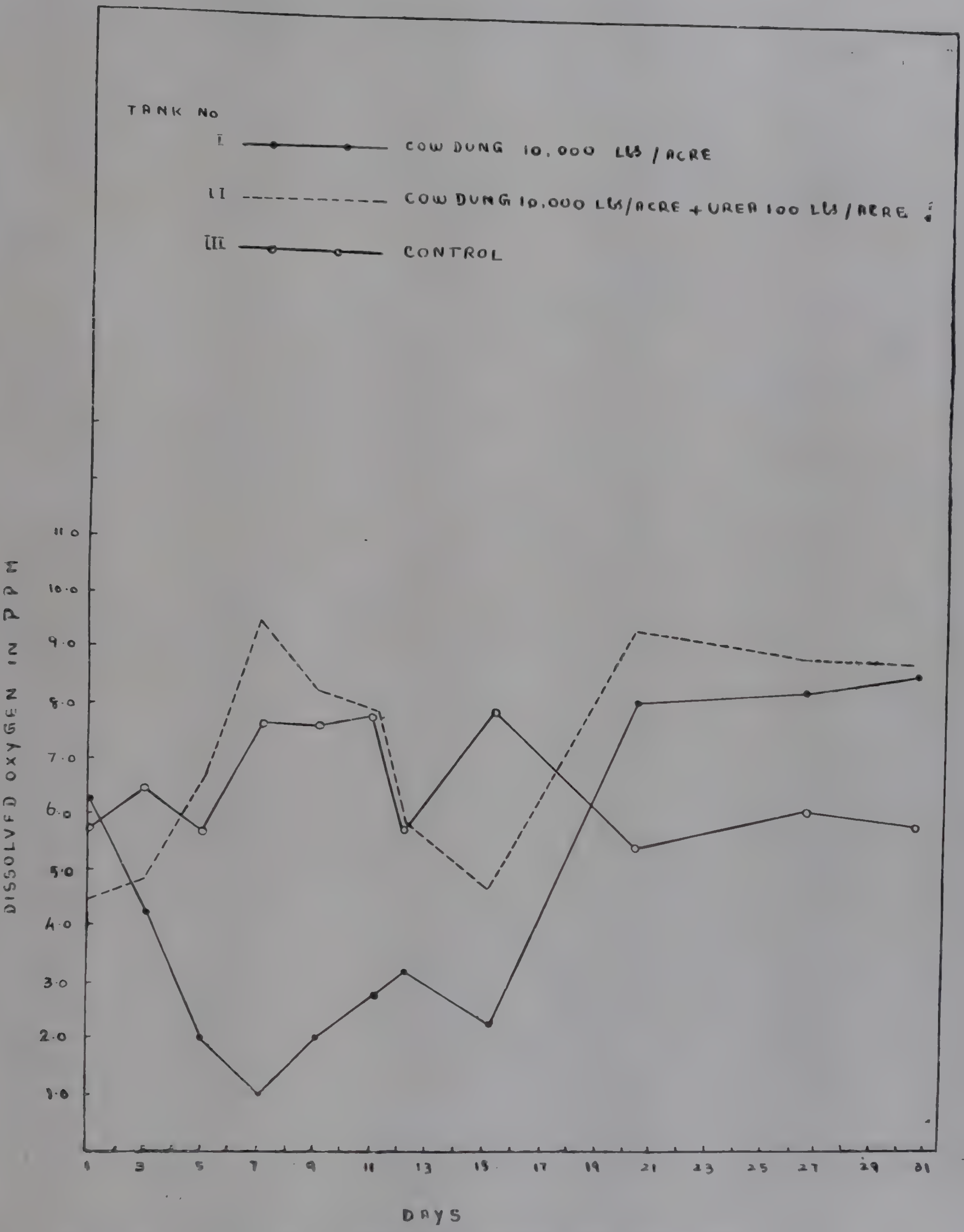


FIG. 2 Effect of cowdung and chemical fertilisers on dissolved oxygen content of water.

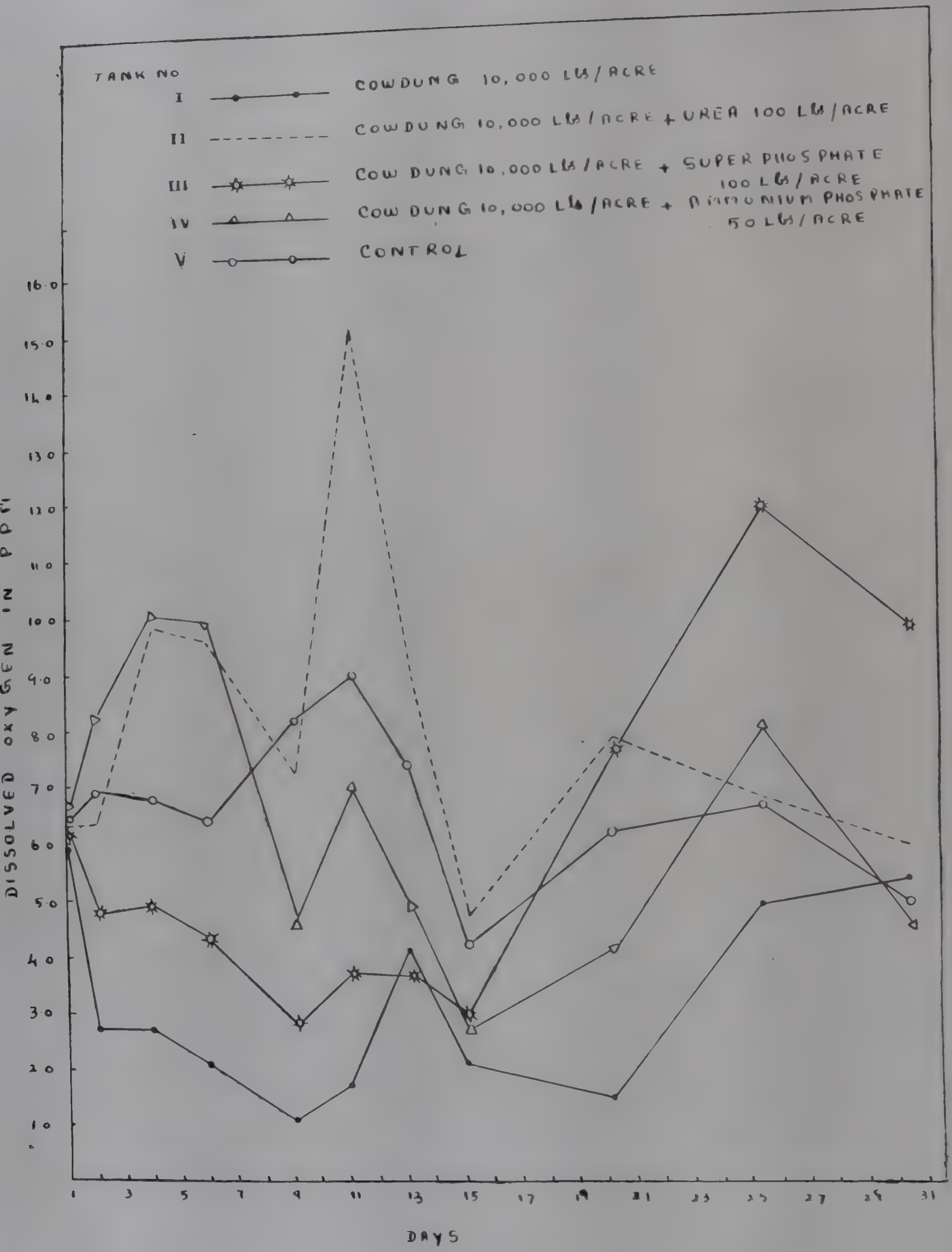


FIG. 3. Effect of cowdung and chemical fertilisers on dissolved oxygen content of water.

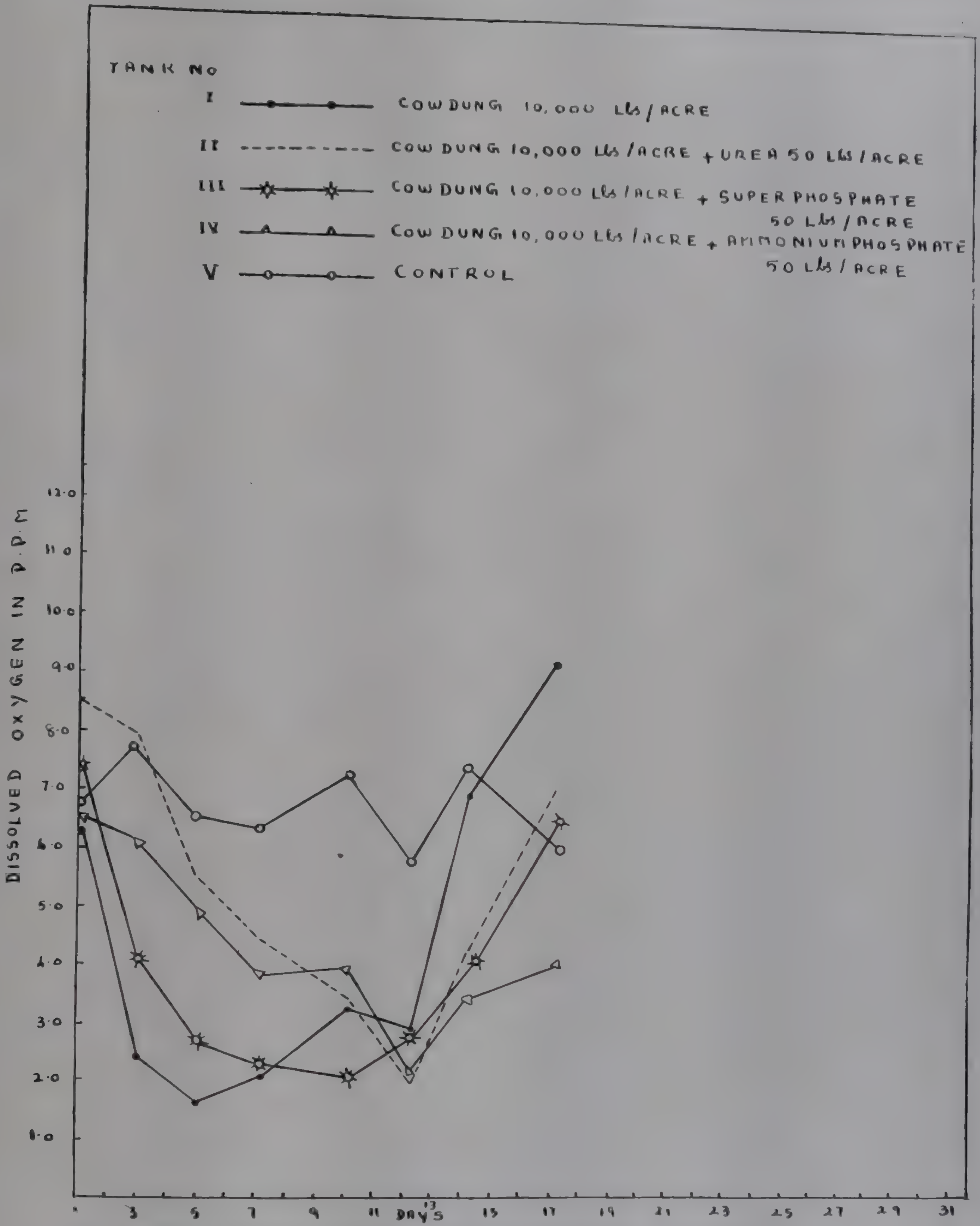


FIG. 4 **Effect** of cowdung and chemical fertilisers on dissolved oxygen content of water.

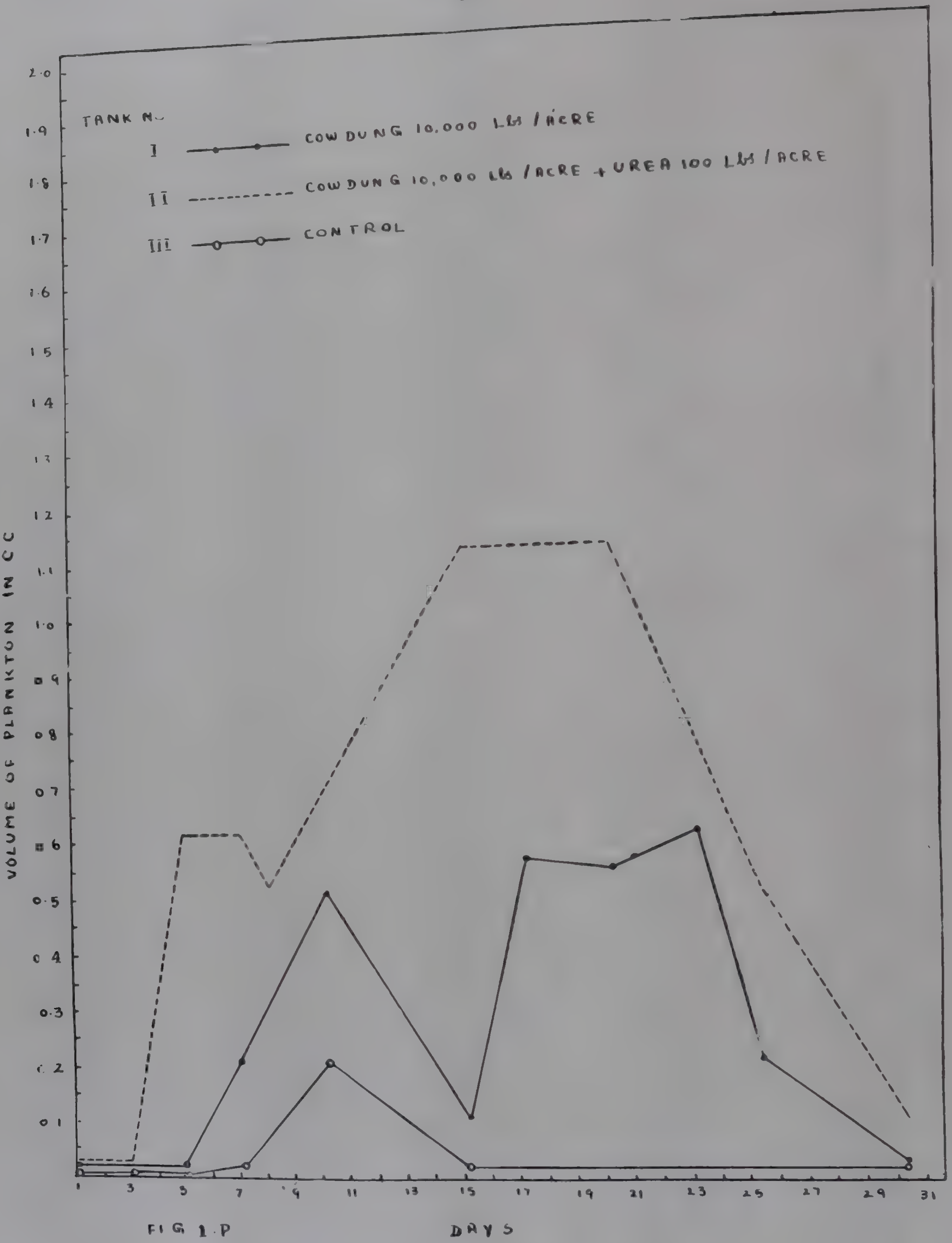


Fig. 1,P. Effect of cowdung and chemical fertilisers on Plankton Production.

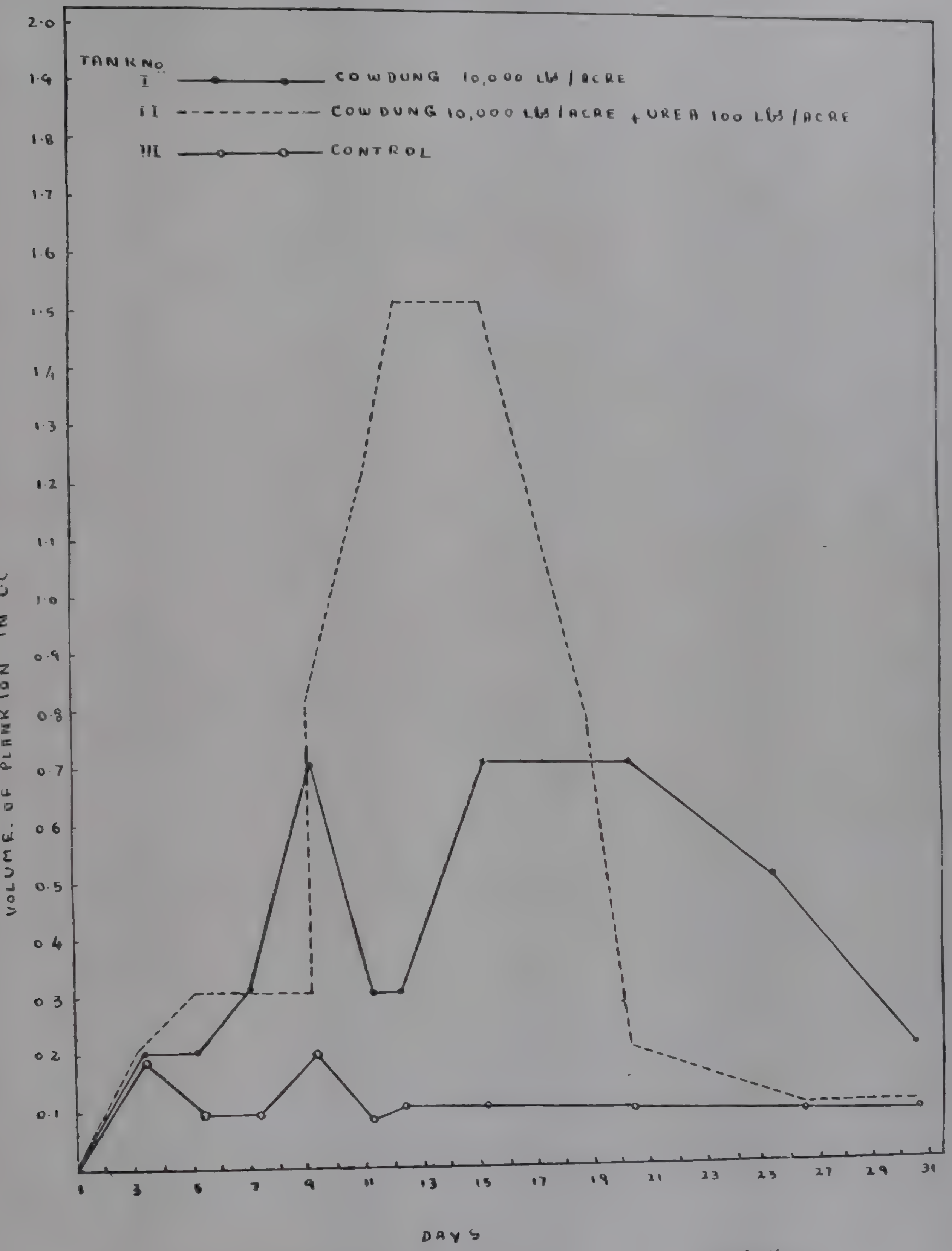


Fig. 2.P. Effect of cowdung and chemical fertilisers on Plankton Production.

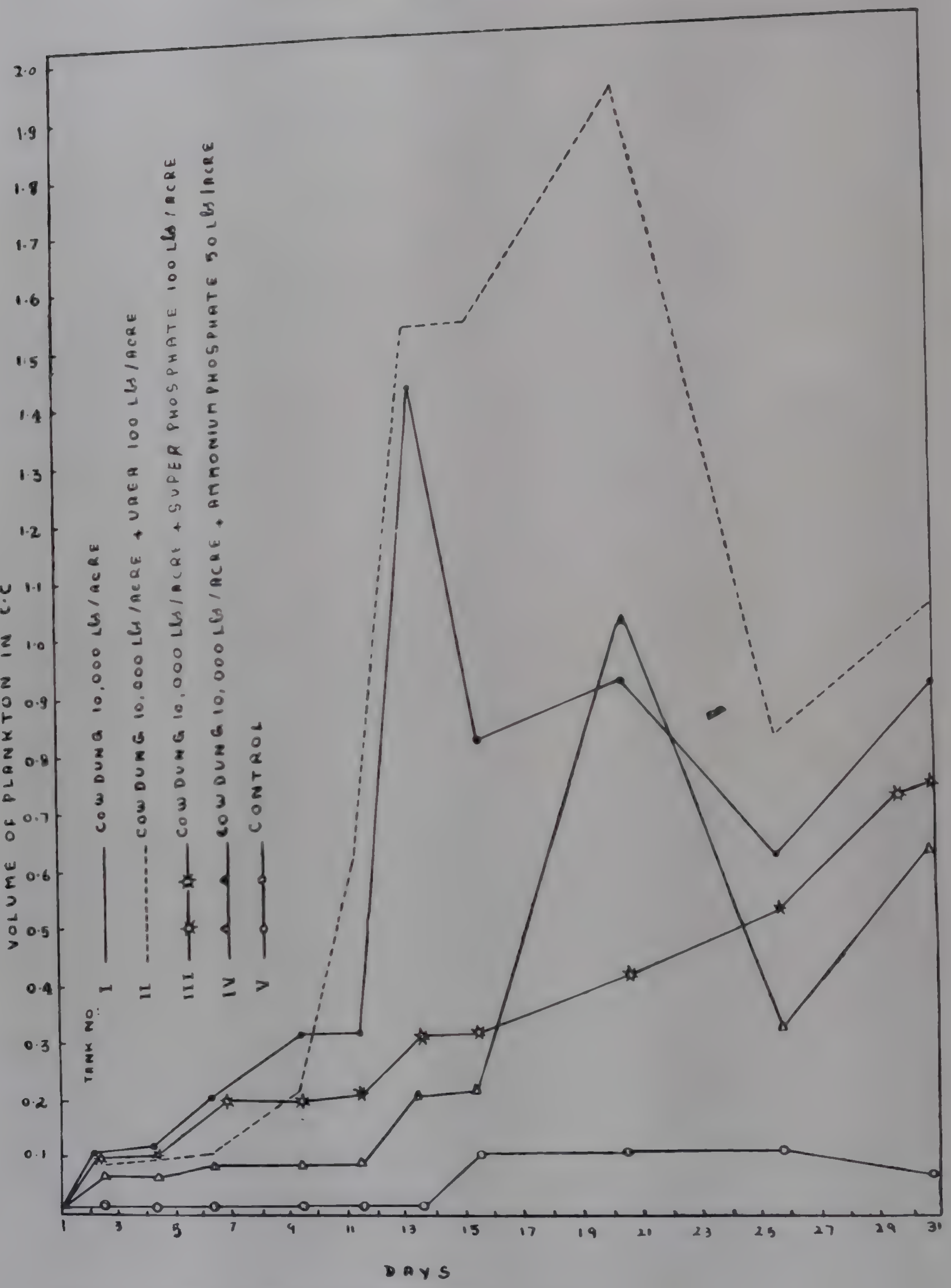


FIG. 3.P. Effect of cowdung and chemical fertilisers on Plankton Production.

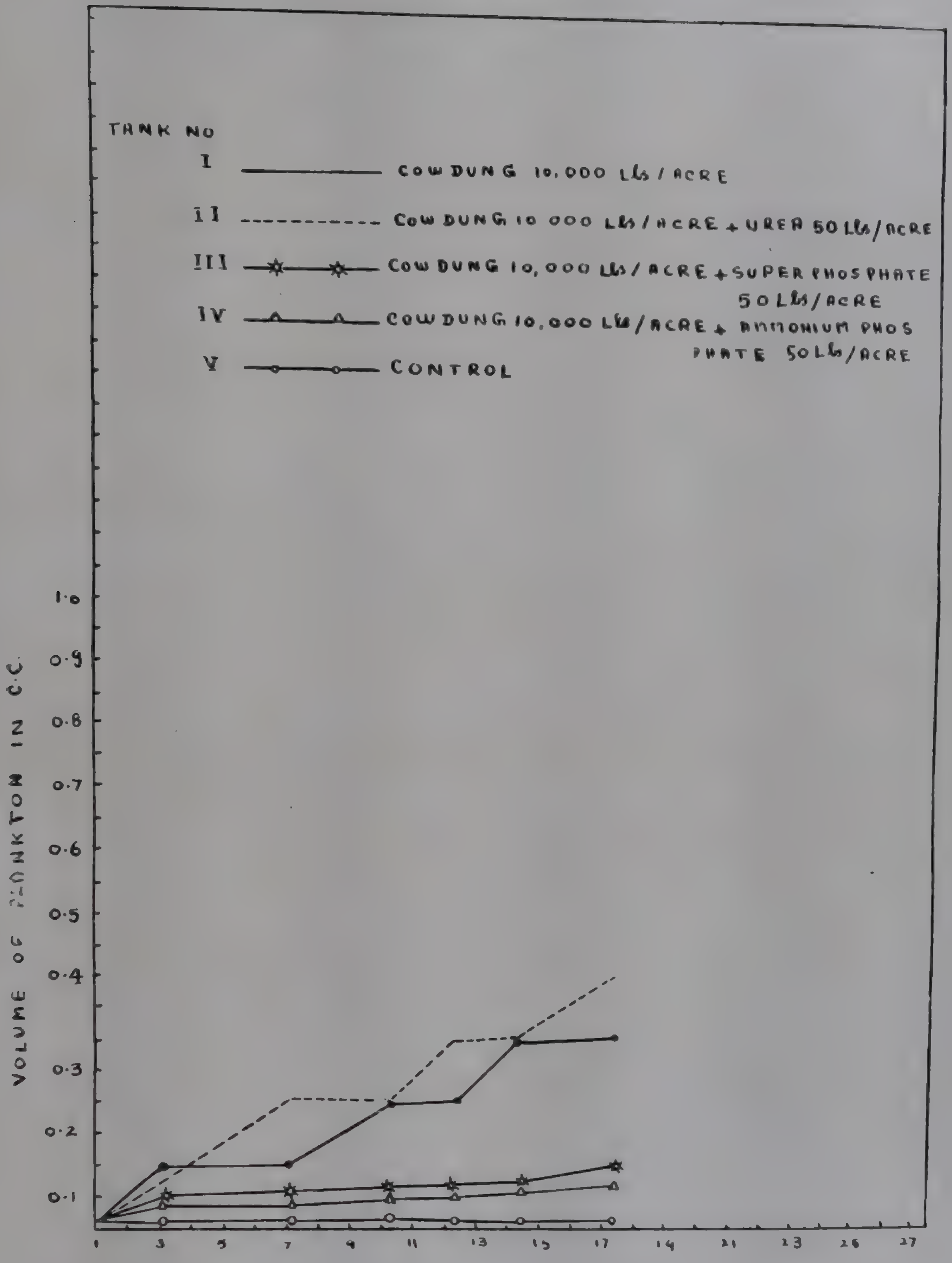


FIG 4 P

FIG. 4.P Effect of cowdung and chemical fertilisers on Plankton Production

CONDITIONS OF EXISTENCE IN TWENTY PEARL BANKS IN THE GULF OF MANNAR OFF TUTICORIN DURING 1962-63.

By

P. I. CHACKO AND P. S. SAMBANDAMURTHY.

The Gulf of Mannar is well known for its fisheries including those of pearl oysters and chanks. Consequently the ecological conditions of the area is being studied at the Marine Biological Station, Tuticorin, and mention may be made of the studies made by Chidambaram and Rajendran (1951), Chidambaram, Rajendran and Valsan (1951) and Chacko and Rajendran (1959).

The present account deals with the observations on the hydrobiological conditions of the following twenty pearl banks inspected during 1962-63:—

* (1) Vaipar periya par.
(2) Devi par.
(3) Parnandu par.
(4) Paduthamarikkan thundu par.
(5) Cruxian par.
(6) Cruxian thundu par.
(7) Kilathi par.
(8) Athuraiarupagam par.
(9) Vanthivuarupagam par.
(10) Pulipoondu par.
(11) Kanapulipoondu par.
(12) Kanathivauarupagam par.
(13) Kanathivuthundu par.
(14) Thollayiram par North.
(15) Thollayiram par Middle.
(16) Thollayiram par South.
(17) Melombathu par.
(18) Athombathu par.
(19) Kodamuthu par.
(20) Saithukodamuthu par.

The salinity, temperature, oxygen content, silicate and phosphate content were determined by the standard methods. The plankton samples were collected by using a standard plankton net made of bolting silk. The bottom fauna were collected by employing divers.

I. *Physico-Chemical conditions.*

The temperatures of the sea water varied from 26·7 to 29·4 degrees centigrade, the difference between the maximum and minimum being only 2·7 degrees centigrade. The salinity showed a wide range from 11·2 to 33·08 pp. 1,000, the lower salinity was recorded only in par 16 and in all other pars the salinity variation wa not great. The oxygen content of the sea wate varied from 4·41 and 5·35 cc. per litre, th difference between the maximum and minimun being only 0·94 c.c. per litre. In pars 17 18 and 20 the value of the oxygen content wa about 5 c.c. per litre. The carbonate conten did not show marked variation. Phosphate wa high in par 1 and fairly rich in par 6 an negligible in others. Details are given i Table I.

II. *Bological conditions.*

(a) Surface plankton.—The volume of th sediment plankton varied from 5 c.c. to 75 c.c in the eight pearl banks from where plankto was collected, details of which are given i Table II. Plankton was poor in par 18 an abundant in par 14.

The diatoms *Coscinodiscus, Guinardia, Rhizosolenia, Chaetoceros* and *Biddhulphia*, were present in almost all pars except in 19 where thei absence was noteworthy. *Asterionella* wa represented only in par 14 and absent in others

The blue green alga *Trichodesmium* wa abundant in pars 18, 19 and 20 and absent i others.

The protozoans *Peridinium, Ceratium* an *Noctiluca* were found in most of the pa in few numbers except *Noctiluca* which wa found in plenty in par 7. *Dinophysis* an *Tintinnus* were also noticed in few numbers.

The arrow-worm *Sagitta* was represented i few numbers in all the pars except in par 18.

The crustaceans *Copepods* and *Naupli larvae* were found in all the pars except in pa 16 and 18.

Molluscan *larvae of gastropods* were foun rarely here and there and *Pteropods* in pars and 20 also in few numbers.

Of the Tunicates *Oikopleura* were found small numbers in most of the pars, *Salpa* a *Doliolum* were fairly common in par 19 on and nil in others.

---

* The Serial numbers correspond with the numbering of pars in Tables I, II, III and IV.

Fish eggs and larvae were found rarely in pars 7 and 19 and commonly in par 14.

(b) Benthic fauna.—The fauna of the twenty pearl banks were represented by four major phyla, viz., (1) Porifera, (2) Coelenterata, (3) Mollusca and (4) Echinodermata.

It is seen from Tables III and IV that pars 9, 13 and 14 were rich in fauna and all the our phyla mentioned above were well represented. Pars 5, 7, 10, 12, 16 and 19 were epresented by three of the phyla and hence ome next in rank in the abundance of fauna to he first set of pars. There is uniformity in the distribution of fauna in pars 10, 11, 12, 16 and 19 being represented only by the first three phyla and complete absence of Echinodermata. In pars 5 and 7 Coelenterata is absent. Pars 2, 3, 4, 6, 8, 17 and 18 are represented by only any two of the four phyla and falls third in rank. Lastly pars 1, 15 and 20 were represented only by one phyla and hence fall fourth in the abundance and distribution of fauna.

References.

Chidambaram, K. and Rajendran, A.D.I. 1951. " On the hydrobiological data collected on the Wadge bank early in 1949, Joun. Bomb. National Hist. Soc. 49 738–748.

Chidambaram, K., Rajendran, A.D.I, and Valsan, A. P. 1951. " Certain observations on the hydrography and biology of the pearl bank Thollayiram par, Off Tuticorin in Gulf of Mannar in April 1949, Joun. Madras University, 21, 48–74.

Chacko, P. I. and Rajendran, A. D. I. 1959. " Maritime Meteriology and Hydrography of Tuticorin Bay, Gulf of Mannar, 1950–54. Fish. Stn. Reports and Year Book. April 1955—March 1956.

TABLE I.

Showing Hydrographical Conditions of Twenty pearl banks in 1962–63.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Surface temp. c.	28·2	28·9	29·4	28·3	27·8	28·3	28·0	27·8	27·8	27·8
Salinity 0/00	33·0	32·8	32·9	32·9	29·5	29·1	29·3	29·2	29·7	29·3
Oxygen c.c./litre	4·41	4·58	4·58	4·64	4·87	4·87	4·7	4·7	4·81	4·88
Carbonate m.gm./1	76·1	77·0	78·0	76·3	78·7	77·0	75·2	73·5	73·5	73·7
Silicate Mu.gm./1	2·5	2·5	Trace.	2·5	Nil.	Nil.	10	10	3·0	4·0
Phosphate Mu.gm./1	8	4·5	Trace.	4·5	4	6	Nil.	Nil.	Nil.	Nil.

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Surface temp. c.	27·8	27·8	28·3	28·0	28·3	27·8	27·8	28·3	26·7	27·0
Salinity 0/00	29·3	29·3	29·3	29·2	33·1	11·2	29·6	29·6	31·4	31·4
Oxygen c.c./litre	4·90	4·70	4·75	4·50	4·45	4·80	5·09	5·23	4·74	5·35
Carbonate m.gm./1	72·7	74·5	75·0	75·5	73·6	72·5	75·5	76·5	78·5	76
Silicate Mu.gm./1	5·0	5·0	13·0	25·0	Trace.	30	50	35	18·0	19
Phosphate Mu.gm./1	Nil.	Nil.	Nil.	Nil.	Trace.	Nil.	Nil.	Nil.	Trace.	Trace.

TABLE II.

Showing the ditribution of surface plankton of eight pearl banks in 1962–63.

	1(1)	2(7)	3(14)	4(15)	5(16)	6(18)	7(19)	8(20)
Diatomeae.								
Coscinodiscus	R	F	P	R	R	..	..	P
Guinardia	R	..	P	..	..	R	..	P
Rhizosolenia	R	..	P	..	R	C	..	R
Chaetoceras	P	R	F	..	..	R	..	..
Biddulphia	R	..	..	C	R	C	..	..
Asterionella	..	..	R	..	..	..	..	..
Schizophyceae.								
Trichodesmium	..	..	..	..	..	S	S	P
Protozoa.								
Dinophysis	..	..	..	F	R	..	..	..
Peridinium	..	..	R	R	R	R	..	R
Ceratium	..	R	R	C	R	R	..	R
Noctiluca	R	P	..	R	R	R	..	..
Tintinus	..	..	..	R	..	..	..	R
Chaetognatha.								
Sagitta	R	R	R	R	R	..	C	R
Crustacea.								
Copepodes	R	P	R	P	..	R	R	C
Nauplius larvae	R	C	R	C	R	..	R	C
Zoea	..	R	..	..	..	..	..	..
Mollusca.								
Gastropod larvae	R	..	..	..	R	..	R	..
Pteropods	..	..	..	..	..	..	R	R
Echinodermata.								
Echinoderm larvae	..	..	..	R	..	..	..	..
Tunicata.								
Oikopleura	..	F	R	R	R	..	..	R
Salpa	..	..	..	..	R	..	C	..
Doliolum	..	..	..	..	..	..	C	..
Pisces.								
Fish eggs and larvae	..	R	C	..	..	..	R	

NOTE.—P=Plenty. C=Common. F=Few. R=Rare.

The figures within brackets indicate the number of the pearl bank as in the text.

TABLE III.

Showing the distribution of bottom fauna of twenty pearl banks in 1962–63.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Sponges.																				
Spirastrella	..	..	..	..	R	R	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Petrosia	..	..	..	..	..	R	..	..	..	C	C	..	..	..	..	R	R	..	..	..
Raspailia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	R	..
Aulospongus	..	R	R	..	R	..	R	..	C	C	P	C	C	R	C	..	R	..	R	..
Phakellia	C	C	P	C	..	..	C	..	P	P	..	P	P	P	..	P	P	R	P	R
Megalopastas	..	..	..	R	..	..	..	..	R	R	R	P	R	R	R	..	..	R	..	.
Hircinia	..	..	..	..	R	R	P	R	R	..	R	R	R	..	R	..	..	..	..	..
Ceraochalina	..	..	C	P	C	R	R	C	..	C	P	P	..	R	P	C	C	T	R	..
Coelenterata.																				
Sertularia	..	..	..	..	..	..	..	P	..	..	..	..	..	..	..	..	..	..	..	..
Spongodus	..	..	..	..	..	..	..	..	R	..	..	..	R	..	..	..	..	R	R	..
Alcyonium	..	..	..	..	..	..	R	..	R	R	C	C	R	.	R	R	..	..	R	R
Gargonia	R	C	..	R	..	..	..	R	R	R	C	..	R	..	..	..	R	..	R	C
Penatula	..	..	..	..	..	..	..	..	..	..	..	R	..	..	..	..	..	..	..	..
Fungia	C	..	..	..	..	R	..	R	..	..	R	..	..	R	..	R	..	R	..	R
Poritis	..	..	..	..	..	..	C	R	..	..	..	..	..	C	R	..	..	..	..	..
Lytocarpus	R	..	R	..	..	..	..	..	..	..	..	C	..	..	..	..	..	..	..	..
Dead corals	..	..	C	P	P	..	C	P	P	P	P	P	P	C	P	P	P	P	P	..
Mollusca.																				
Murex	R	..	R	R	..	..	..	C	..	..	..	..	..	..	..	..	..	..	..	..
Pinna	..	R	..	P	P	..	..	P	C	R	R	..	..	..	..	..	..	R	..	..
Conus	..	..	..	..	..	..	R	..	R	R	..	..	R	..	..	..	..	..	R	..
Modiola	C	C	C	C	P	P	..	..	..	..	C	..	..	..	..	..	..	..	..	R
Pecten	..	..	..	R	..	..	..	R	..	..	..	..	..	..	..	..	..	..	R	..
Cardium	..	..	R	..	R	..	..	..	..	..	..	..	..	..	..	C	..	..	..	..
Pinctada	..	R	..	..	R	R	..	R	R	..	..	..	..	..	..	..	..	..	..	..
Pinctada dead shells	R	P	..	..	P	P	P	C	P	P	P	P	P	P	P	P	P	C	P	..
Xancus pyrum	R	..	..	..	..	..	R	..	..	..	..	..	..	..	..	..	..	..	..	..

Echinodermata.

Antedon	C	R	R	..	..	..	..	R	..	..	..	R	..	..	..	..	..	R	R	..
Holothuria	..	P	C	..	R	..	..	..	..	..	..	..	..	R	R	R	..	..	..	..
Salmacis	..	P	R	..	..	..	..	..	..	..	..	..	..	..	P	..	..	..	..	..
Clypeaster	..	..	..	R	R	R	R	R	..	..	..	..	..	R	..	..	..	P	..	C
Luida	R	..	..	..	R	R	..	..	..	..	R	R	..	..	..	R	..	..	..	..
Pentaceros	R	P	R	..	P	C	P	..	P	..	..	..	P	P	R	..	..	..	C	C

(NOTE.—P=Plenty. C=Common. R=Rare.)

TABLE IV.

Showing the abundance and distribution of the four groups of fauna of the twenty pearl banks—1962–63.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Sponges	..	..	P	P	P	..	P	..	P	P	P	P	P	P	P	P	P	..	P	..
Coelenterata	..	..	..	..	..	P	..	P	P	P	P	P	P	P	..	P	P	P	P	..
Mollusca	P	P	..	P	P	P	P	P	P	P	P	P	P	P	..	P	..	..	P	..
Echinodermata	..	P	P	..	P	..	P	..	P	..	..	..	P	P	..	..	..	P	..	P

NOTE.—P = Plenty 1·20 Pearl banks.

REPORT ON THE SURVEY OF PEARL BANKS OFF RAMANATHAPURAM COAST DURING 1965.

BY

A. D. ISAAC RAJENDRAN AND FREDA CHANDRASEKARAN.

Introduction.

The occurrence of pearl oysters in Palk Bay off Tondi and Rameswaram and in Gulf of Mannar off Pamban and Kilakarai though not of commercial importance have been known for many decades (James Hornell 1922). The only known pearl fishery was conducted in 1914 in the beds off Tondi, the beds having been discovered in 1913 by James Hornell (1916). No deposits of pearl oysters were found in the Palk Bay since 1914 in spite of periodical inspections. The last inspection of the banks off Tondi was conducted in 1958 and the banks were found to be barren except for two oysters fished during the inspection (Choodamani, N. V., 1962).

The inspection of the beds off Rameswaram, Kilakarai and Tondi comprising the third or Northern division of the Madras Pearl Banks was undertaken during September 1965 with a view to ascertain the presence of pearl oysters and the population of oysters if any and to have a precise knowledge of the topography and the ecology of the banks.

Equipments and Methods.

The inspection was conducted in three stages, first stage with the base at Rameswaram to cover the pars Kothandaraman Koil Neir, Nadu Par, Kanniga Par, Narikuzhi Par, Velangu Par and Kondal Par. Next the inspection of the pars off Damodaran Pattinam, Pasipattinam, Tondi and Karangadu banks were taken up with base at Tondi. Finally the pars Appa Tivu Velangu Par, and Appa Tivu Karai Par, Kizhingnan Par, Usman Challi Par and Valai Theevu Karai Par were inspected with base at Kilakarai. The entire inspection took 14 days including the shifting of camp from one place to another.

The inspection party comprised of the Assistant Director of Fisheries (Pearl and Chank), Inspector of Fisheries (Pearl), Research Assistant (Pearl and Chank), Research Assistant (Hydrography), Sub-Inspector of Fisheries (Pearl Bank), the departmental divers and the Parmandadi. The Pablo boats IB 32 and IB 83 were utilised as the survey vessels. Two departmental divers were employed in each boat for skin diving and Aqua lung diving. Normally skin dives were made; for detailed observations at interesting spots aqua lung dives were resorted to. When the par to be inspected was reached, water samples from bottom and surface were collected using Knudsens' Reversing water sampler. Temperature was recorded immediately. Simultaneously plankton sample was also collected by towing a Bolting silk net 50 mm. dia for 15 minutes at 0·5 knot speed. The fauna, flora, depth, nature of bottom, number of oysters in each dive, were all noted in a data sheet. The following pars were inspected on the dates noted against each.

Base at Rameswaram. (1)	*Date.* (2)
(1) Kothandaraman Koil Neir ..	6th September 1965.
(2) Nadu Par	7th September 1965.
(3) Kanniga Par	8th September 1965.
(4) Narikuzhi Par	9th September 1965.
(5) Vilangu and Kondal Par	10th September 1965.
Base at Tondi.	
(1) Pars off Damodara Pattinam and Pasipattinam.	13th September 1965.
(2) Pars off Damodara Pattinam and Pasipattinam and Tondi Pearl Bank.	14th September 1965.
(3) Karangadu Bank and Pariyamman Munai par.	15th September 1965.
Base at Kilakarai.	
(1) Appa Tivu Vilangu Par, Appa Tivu Karai Par, Kizhingnan Par.	17th September 1965.
(2) Usman Challi Par, Valai Theevu Karai Par.	18th September 1965.

Results of Inspection—Rameswaram.

The summary of the results are furnished in Table I.

The inspection of the beds off Rameswaram was conducted for five days. The depth of the beds inspected varied from 2 to 6 fathoms. Current was from North to South on 6th, 7th and 9th September 1965 and from South to North on 8th and 10th September 1965. Except on 10th September 1965 clarity was fairly good on all the days. Sea was very rough with heavy winds on 10th September 1965 and on other days the sea was relatively calm.

The water was warm with surface temperature varying from 28·7° C to 29·6° C. The temperature was higher at the surface than at the bottom on 6th September 1965. No difference in temperature was noticed between surface and bottom on 7th September 1965 and on subsequent days the reverse conditions were observed bottom temperature being higher than the surface. This may probably be due to the change in the direction of the wind and current (from North-South to South-North).

Salinity value was high and no variations were noticed between surface and bottom on most of the days. However higher salinity at surface on 6th September 1965 and at bottom on 10th September 1965 were recorded.

The net volume of plankton ranged from 16 c.c. to 39 c.c. in the various pars, highest volume of 39 c.c. being found in Kanniga Par. In all the plankton collections off Rameswaram, Phytoplankton were abundant, especially Coscinodiscus spp. and Chaetoceros spp. Among Zooplankton, copepods were found in large numbers in some of the collections. The occurrence of Noctiluca sp. was an important feature in this area. Other Zooplankton noticed were Ceratium spp., Nauplii, Medusoids. Zoea, Mysis, Larval prawns and Sagitta spp.

The Banks inspected were mostly rocky except in Kothandaraman Koil Neir where a mixture of sand and mud was encountered. In the sandy bottom of Kothandaraman Koil Neir and Nadu Par numerous chanks were present. The chanks fished were returned to the sea. Two live oysters from Kothandaraman Koil Neir and one oyster from Nadu Par were fished out. The oysters were Pinctada Chemnitzi. Star fishes and Astropecten were especially abundant in these two pars. Echinnus, Holothuria and dead shells were also obtained in considerable numbers during diving. The characteristic fauna in the rest of the pars off Rameswaram were Alcyonarians, Gorgonids and Sponges. Ascidians, Pinna spp Murex spp chanks and corals were occasionally met with. Sea weeds such as Gracillaria spp, Uulva Spp and Sargassum spp were present in almost all the pars and in abundance in Narikuzhi and Velangu par. However no sea weeds were found in Kothandaraman Koil Neir.

Tondi.

The banks off Tondi were inspected for three days from 13th to 15th September 1965. Pars off Damodarapattinam, Pasipattinam, Tondi Bank, Karangadu Bank, Pariyamman Munai Par and another par indicated by the local mandadi were surveyed in detail. Very calm conditions prevailed during all the days of inspection with very good clarity. Current was from North to South.

Unlike in the pars off Rameswaram, the temperature distribution in the pars off Tondi were uniform, the surface temperature being higher than the bottom.

Salinity was high with very little variation between surface and bottom. Salinity varied from 35·62 per thousand to 35·73 per thousand.

Phytoplankton were represented in very large quantities than Zooplankton. Thallasiothrix spp, Chaetoceros spp and Coscinodiscus spp were mainly represented. In the collection of 15th September 1965 Zooplankton was not at all found except some stray Ceratium tripos. On other days the Zooplankton noticed were Copepods, Noctiluca spp, Zoea, Nauplii, larval polychaetes, Larval Gastropods and fish eggs

The bed was sandy at $2^1/_2$ to 4 fathoms level but fine sand was found at 6 fathoms level in the pars off Damodarapattinam and Pasipattinam. The main fauna in this region consisted of Modiola spp, Bivalves, Polychaete-tubes and chanks. However no oysters were obtained. In the rocky patch indicated by local mandadi having the bearing Thondi Light House 270°, Damodarapattinam 334°. Pasipattinam 350°, the fauna represented were Astropecten spp, Brittle Star, dead shells and dead corals. Gracillaria spp and other algae were also present. But the area did not contain any pearl oyster. The bed of Tondi pearl bank next inspected was a mixture of sand and mud. The fauna in this locality were Hydroids, Polyzoans, dead shells and sea weeds. One young oyster spat was obtained. At six fathoms depth the water was very turbid and clarity nil.

The Pariamman Munai Par opposite to Sholiangudi village was surveyed on 15th September 1965. The bottom was rocky covered with sand and mud. The fauna consisted of dead shells, star fishes, cake urchin, Chiton spp, Strombus sp., and Gracillaria spp. Karangadu bank lying seven miles South-East off Tondi at five fathoms limit was also inspected on the same day. Echinoids, Polychaete-tubes and dead shells were found in considerable numbers. Coral bits, Modiola spp, broken shells, and egg mass of Sepia were also got during diving. No oyster was found in both the pars surveyed though a total of ninety dives were made.

Kilakarai.

The inspection of banks off Kilakarai was conducted for two days on 17th and 18th September 1965. The pars inspected were Appa Tivu Vilangu Par, Appa Tivu Karai Par, Kizhinghnan Par, Usman Challi Par and Valai Theevu Karai Par. The current was from South to North on both the days and wind South-West. Sea was very rough on 17th September 1965 while it was comparatively calm on 18th September 1965. High waves and heavy winds prevailed on both the days. Clarity was very poor on 18th September 1965.

Higher temperature at bottom on both the days was particularly interesting to record. A similar pattern was observed in the pars off Rameswaram on few days. This was in striking contrast to the temperature distribution in the pars off Tondi in Palk Bay, where the surface temperature was higher than the bottom. Another noteworthy feature was that comparatively higher salinity was recorded in the pars off Kilakarai.

The plankton in the pars off Kilakarai present an entirely different pattern, Zooplankton predominating over phytoplankton. Coscinodiscus spp, Biddulphia spp Chaetoceros spp, Trichodesmium spp and Rhizosolenia spp were the phytoplankton observed. Among Zooplankton, Zoea, Nauplii, Larval polychaetes, Larval bivalves and Oikopleura were also found. The total volume of plankton was lower than in Rameswaram and Tondi.

The bed was rocky covered with sand in all the pars surveyed off Kilakarai. In Appa Tivu Vilangu Par lying east of Kilakarai at nine fathoms limit, the water was turbid and clarity nil. Since the sea became dangerous, diving was stopped after four dives. Appa Tivu Karai Par and Kizhingnan par were next inspected. The chief fauna and flora in these two pars were Hydrozoans, Polyzoans, Zuberogorgia, dead coral pieces and plenty of sea weeds. The bottom and rock formation in Kizhingnan Par resembled the banks off Tuticorin and are suitable for oyster deposition. A total of sixty-two dives were made but no live oysters were fished.

The depth varied from $2\frac{1}{2}$ to $3\frac{1}{4}$ fathoms in Usman Challi par and Valai Theevu Karai Par. The main fauna in both these pars inspected on 18th September 1965 were Gorgonids, Aulospongus spp, Antedon spp, Holothuria, Zuberogorgia spp Nullipores, Alcyonarians, dead shalls and coral bits. One very young oyster was fished from Valai Theevu Karai Par at $2\frac{1}{2}$ fathoms depth. Sea weeds were found in abundance in these pars principally Padina spp. Algal population was very rich and dense in Valai Theevu Karai Par.

Summary.

Three live oysters at Rameswaram, one live oyster at Tondi and one live oyster at Kilakarai were fished out during the entire operation. These oysters belong to the species Pinctada Chemnitzi. The oysters that were fished out at Tondi and Kilakarai were very small, more or less in the spat stage. In view of the extensive and detailed survey conducted the yield of five oysters can be considered to be only as stray occurrences and the banks off Rameswaram, Tondi and Kilakarai were recoreded as barren.

Acknowledgements.

Our thanks are due to Thiru B. Jayabaskaran and Thiru B. A. Selvaraj for their contribution for the survey of the pearl banks.

References.

(1) Choodamani, N. V. and S. Mahadevan 1962—Report on the inspection for pearl oyster beds off Tondi (Rameswaram district) and Mallipatnam in Palk Bay (Thanjavur district) during September 1958. Fisheries Station Reports and Year Book 1957-58—Page 99.

(2) James Hornell 1916—Marine Fishery Investigations in Madras. Madras Fisheries Bulletin No. VIII.

(3) James Hornell 1922. The Indian Pearl Fisheries of the Gulf of Manner and Palk Bay. Madras Fisheries Bulletin **XVI.**

TABLE I.

Date.	6th September 1965.		7th September 1965.		8th September 1965.		9th September 1965.		10th September 1965.	
Locality.	*Kothandaraman koil neir.*		*Nadu par.*		*Kanniga par.*		*Narikuzhi par.*		*Vilangu par and Kondal par.*	
	S	B	S	B	S	B	S	B	S	B
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Nature of Bottom	Sand and Mud.		2"—6" of mud over par.		2"—5" of mud over rock.		Flat Rock.		Flat Rock.	
Depth in fathoms	3 to 4½		4 to 4¾		4 to 4¾		2 to 5		5 to 6	
Wind	W		NE		SW		NE			E
Current	NS		NS		SN		NS			SN
Temperature °C	29·6	29·1	29·1	29·1	28·6	29·0	28·9	29·6	28·7	29·0
PH	8·4	8·4	8·4	8·4	8·4	8·4	8·4	8·4	8·4	8·4
Salinity ‰	35·62	35·50	35·62	35·62	35·62	35·62	35·62	35·73	35·91	35·91
Si-Sio4 Mu. gm. at/L	Nil	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
P-Po4 Mu. gm. at/L	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Calcium mg. at/L	9·9	9·7	10·15	10·15	9·7	9·7	9·9	9·9	10·45	10·45
Dissolved Oxygen Ml/L	4·3	4·2	4·1	4·9	4·1	4·1	3·9	4·0	4·2	4·2
Total Dives	114		94		107		94		59	
Oysters fished	Two		One		Nil		Nil.		Nil.	
Other fauna	Astropecten, Holothuria Chanks, Virgularia, Dead shells, egg capsules of molluscs Pecten, Polychaetes.		Echinnus, Astropecten, dead shells, Chanks, Pinna, Murex, Sponge egg capsules of mullusc and Alcyonarians.		Coral Pieces, Chanks, Gorgonids, Alcyonarians dead shells, Aulosponges egg-capsule of chanks, Pinna and Echinnus.		Alcyonarians, Gorgonids, Holothuria, Dead corals, Dead shells, various types of sponges.		Gorgonids, Alcyonarians, Polychaetes, Ascidians, Tube sponges, Echinus and chanks.	

S=Surface.
B=Bottom.

TABLE I—*cont.*

Date.	*13th September 1965.*		*14th September 1965.*		*15th September 1965.*		*17th September 1965.*		*18th September 1965.*	
Locality.	*Pars off Domodaranpattinam and Pasipattinam,*		*Tondi Pearl Bank.*		*Karangadu Bank Pariamman Munai par.*		*Appativu Vilangupar Kizhingnan par.*		*Usman challi par Valaithirukarai par.*	
	S	B	S	B	S	B	S	B	S	B
	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Nature of bottom	Sand and fine sand	..	Sand mixed with mud	..	Mud and sand	..	Rock and sand	..	Flat Rock with sand spread.	
Depth in fathoms	2½ to 6		2½ to 6		5 to 6		8¼ to 9		2½ to 3½	
Wind	N		E		N		S		W	
Current	NS		NS		NS		SN		NS	
Temperature °C	29·7	29·6	29·95	29·7	29·5	29·6	29·7	29·2	29·5	28·8
PH	8·4	8·4	8·4	8·45	8·45	8·45	8·45	8·45	8·4	8·4
Salinity °₀o/°	35·73	35·62	35·73	35·62	35·62	35·62	35·99	35·99	36·99	36·22
Si-Sio4 Mu. gm. at/L	Nil.	Nil.	Nil .	Nil.	Nil.	16·6	16·6	16·6	Tr.	Tr.
P-Po4 Mu. gm. at/L	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
Calcium mg. at /L	10·45	10·15	10·45	10·75	11·15	10·45	10·45	10·75	9·7	9·7
Dissolved Oxygen Ml/L	5·4	6·9	4·3	4·6	4·1	4·1	4·3	4·3	4·2	4.1
Total Dives	69		108		90		62		67	
Oyster fished	Nil.		One.		Nil.		Nil.		One.	
Other fauna	Tube sponges, Chanks, Barnacles, Clypeaster Astropecten, Compound ascidians, Dead bivalves.		Polychaetes, Hydroids, Alcyonarians, Dead shells, Chiton, Polyzoans, Barnacles Coral-pieces, dead shells, chanks,.		Echinnus, Polychaete, tubes, Hydroids strombus.,		Zuberogorgia, Hydrozonas, Polyzoans, Area, broken shells, Dead corals, sponges.		Gorgonids, Alcyonerians, Polychaetes,	Antedon, sponges. Clyplerster.

S = Surface
B = Bottom

PRELIMINARY OBSERVATIONS ON CHANK MARKING EXPERIMENTS CONDUCTED AT TUTICORIN, GULF OF MANNAR, DURING 1962-63.

By

P. S. SAMBANDA MURTHY AND P. I. CHACKO.

Introduction.

From time immemorial the sacred chank, *Xancus pyrum* has been exploited as a commercial fishery in a systematic and organised way in the Madras State. The Chank Fishery gives employment to thousands of divers. On an average the Madras State Government gets an annual revenue of about ten lakhs rupees. The fishery owes its existence due primarily to the fact that bangles made out of chank shells are being fancied as an ornament by women of Bengal and neighbouring States.

The fishery.

The season for the fishery starts by the end of October or beginning of November. The catches of the divers who provide their own canoes are brought to the Government Chank godown and graded into three categories of full-sized, undersized, wormed chanks. The full-sized are those whose diameter is over 2·4 inches across the widest part. According to statistics (Chacko and Palani, E. 1959) the average number of full-sized chanks fished by a diver is fifteen per day which give him in earning of Rs. 5·60 Paise per day.

Geographical distribution and Ecology of Chank beds.

The geographical distribution of the Indian Chank is confined to the southern coastal waters of East and West coast of India. In the West coast it is found off Kathiwar coast with a sudden disappearance of the variety as we go south till the southern coast line of Travancore where it is again found. In the East coast it is more extensively distributed, being found all along the coast of Cape Comorin to as far north as Nellore district. It inhabits comparatively shallow waters of a sandy bottom mixed with moderate amount of mud. It is in such sandy tracts that the tube dwelling *Trebellid* polycheate worms are found which form the main food of the chanks. Other favourite sea bottom for chanks are the rocky edges of reefs with sandy patches in-between the rocks, as the polycheates on which they live are found in abundance in such surroundings also.

Previous work.

Hornell (1914 and 1915) has traced the history of Chank fishery in India and their relation to Hindu Life and Religion. He has also briefly described the life history and local races of chanks. Moses (1923) described the anatomical characters of chanks. Devanesan and Chacko (1944) gave an account of the bionomics and Chidambaram and Unny (1944) made certain observations on the development of the chank. Chacko and Rajendran (1956) gave a brief account of the chank fishery of Tuticorin, and Chacko and Palani (1959) made a statistical analysis of the chank fishery of Tuticorin. Apart from these there appears to be no account of the study of the Biological aspects of this commercially important gastropd. An attempt is made here to describe the observations made on the rate of growth of the Chank during the year 1962-63.

Materials and methods.

Live undersized chanks were picked up from the Government chank godown during the fishery and brought to the laboratory. They were placed in fresh sea water to keep them alive during the process of marking. A small hole is drilled a few mm. inside from the edge of the lip or labrum of the shell. A serial numbered metal tag is fastened to the shell by passing a fine copper wire through the hole made on the shell. After tagging they were measured. The length was taken from the tip of the apex of the shell to the tip of the spout by means of a vernier steel callipers graduated in millimeters. The diameter was taken where the reading was the highest. Weight in grams was taken with an ordinary spring balance. All these measurements were carefully recorded against the respective serial numbers of the tagged chanks in a printed tabular register. After this the chanks, kept alive in sea water, were taken to the sea in a departmental motor launch and released at the chank bed. The date of marking, the date of release and the place where released were all carefully noted down. In all about 438 specimens were tagged, weighed, measured, and released during the chank fishery season between January and May 1962 for observation on rate of growth.

Recovery of tagged specimens.

During the 1962-63 chank fishery which started towards the end of 1962 and lasted till May 1963, sixteen chanks were recaptured out of the 438 marked. Thus the percentage of recovery of marked chanks for the season worked out to 3·6.

TABLE I.

SHOWING THE GROWTH OF LENGTH AND DIAMETER OF SIXTEEN MARKED CHANKS RELEASED IN THE FISHING SEASON OF 1962–63, ARRANGED IN THE ORDER OF INCREASING NUMBER OF DAYS IN THE SEA.

Serial number and Tag number.		Length when released.	Length when re-captured.	Increase in length.	Diameter when released.	Diameter when re-captured.	Increase in diameter.	Date of release.	Date of recapture.	Total number of days in sea.	Place of release.
		MM.	MM.	MM.	MM.	MM.	MM.				
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	Q. 404 ..	97	100	3	51	56	5	9th May 1962 ..	31st December 1962.	237	Thollayiram.
2	Q. 346 ..	96	100	4	51	55	4	1st May 1962 ..	2nd January 1963.	247	Do.
3	Q. 356 ..	93	95	2	50	52	2	Do. ..	16th January 1963.	261	Do.
4	Q. 330 ..	97	98	1	48	54	6	Do. ..	22nd January 1963.	267	Do.
5	Q. 213 ..	108	109	1	50	53	3	17th April 1962 ..	15th January 1963.	274	Do.
6	Q. 226 ..	98	100	2	51	55	4	18th April 1962 ..	30th January 1963.	288	Do.
7	Q. 364 ..	102	101	1	50	55	5	2nd May 1962 ..	15th February 1963.	290	Do.
8	Q. 362 ..	98	104	6	48	55	7	Do. ..	18th February 1963.	293	Do.
9	Q. 361 ..	103	103	..	50	54	4	Do. ..	2nd March 1963 ..	305	Do.
10	Q. 201 ..	102	104	2	48	55	7	18th April 1962 ..	15th February 1963.	308	Do.
11	Q. 205 ..	106	102	4	50	55	5	Do. ..	19th February 1963.	308	Do.
12	Q. 437 ..	106	111	5	50	56	6	10th May 1962 ..	27th March 1963 ..	322	Do.
13	Q. 406 ..	98	104	6	50	55	5	9th May 1962 ..	24th April 1963 ..	351	Do.
14	Q. 71 ..	98	106	8	51	57	6	9th February 1962.	25th February 1963.	382	Johanmadpur.
15	Q. 87 ..	101	109	8	52	58	6	Do.	11th April 1963 ..	427	Do.
16	Q. 77 ..	102	118	16	51	63	12	Do.	10th May 1963 ..	456	Do.
			Total ..	59			87			5,016	
			Average ..	4·68			5·43			316	

Discussions.

The pattern of growth is not uniform and the two dimensions investigated, viz., length and diameter, do not increase proportionately with the increase in the period of life in the sea. These may be due to several reasons (1) environmental factors such as availability of food, oxygen, salinity, temperature and other conditions of existence; (2) difference in growth rates in different sexes; (3) seasonal variations; (4) lower rate of growth during breeding; and (5) over-crowding and struggle for existence.

This may be due to the chanks spending more energy and food in building up the girth of their shell during certain phases of their life and the length during certain other phases.

TAAEE II.

SHOWING APPARENT RETARDATION AND ARRESTED GROWTH IN LENGTH IN THREE CHANKS.

Serial number as in table I.	*Tag number.*	*Length when released.* MM.	*Length when recaptured* MM.	*Growth.* MM.	*Diameter when released.* MM.	*Diameter when re-captured.* MM.	*Growth.* MM.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
7	Q. 364	102	101	—1	50	55	5
9	Q. 361	103	103	—	50	54	4
11	Q. 205	106	102	—4	50	50	5

Chank Nos. Q. 205 and Q. 364 show retardation of growth in length and Chank No. Q. 361 arrested growth in length. This is due to the fact that while taking the initial length of the chank before release the protoconch or embryonic shell found at the extreme top of the spire which measures from 2 to 5 mm. might have been present during the initial measurement. While taking the measurements after reclamation this might have got broken due to rough handling as they are very brittle. But the chanks have increased in diameter showing that definite growth has taken place during their life in the sea.

Growth rates in selected chanks released in Thollayiram par chank bed.

To avoid confusion the two dimensions studied are treated separately. When individual chanks are selected from the lot and the rate of growth is plotted against the time shown in Table III we find three definite growth progressions in the linear dimensions, as the period of life in the sea increases.

TABLE III.

Serial number. 1	*Environment I.*			*Enviornment II.*			*Environment III.*		
	Tag number.	*Increase in length.* MM.	*Period days.*	*Tag number.*	*Increase in length.* MM.	*Period days.*	*Tag number.*	*Increase in length.* MM.	*Period days.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	330	1	267	356	2	261	404	3	237
2	226	2	288	237	5	322	346	4	247
3	201	2	308	406	6	351	362	6	293
	Total ..	5	863	..	13	934	..	13	777
	Average ..	1·66	288	..	4·3	311	..	4·3	258
	Average per year.	2·2	365	..	5·0	365	..	6·1	365

It may be presumed that these three sets of chanks were growing in three different environmental conditions. In environment I the average rate of linear growth is 2·2 mm. per year. In environment II the average rate of linear growth is 5·00 mm. per year and shows a higher rate from the previous one and in environment III the average rate of lenier growth is 6·1 mm. per year showing the highest rate of growth.

Growth-rate in diameter of selected chanks.

Released in Thollayiram Par.—Taking diameter into consideration the hypothetical growth-rate is discernible more clearly as shown in Table IV below.

TABLE IV.

Environment I.			*Environment II.*			*Environment III.*		
Tag number.	*Increase in diameter.* MM	*Period days.*	*Tag number.*	*Increase in diameter.* MM.	*Period days.*	*Tag number.*	*Increase in diameter.* MM.	*Period days.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
356	2	261	346	4	247	404	5	237
213	3	274	364	5	290	330	6	267
361	4	288	437	6	322	362	7	293
Total ..	14	1,174		15	859		18	797
Average ..	3·5	294		5	286		6	266
Average increase in one year.	4·4			6·3			7·4	

The three environmental conditions show progressively three average rates of growth. In environment I the average rate of growth shows 4·4 mm. in a year, in environment II it is higher 6·3 mm. in a year, and in environment III it is 7·4 mm. in a year.

It will be of interest to note that the two categories of chanks taken above for discussions on rate of growth of length and diameter were all released in the same area, viz., chank bed adjoining Thollayiram par. This is a wide area of about 10 square miles, and it is likely that the chanks were released in different places in the same wide area where the environmental conditions were not uniform.

Growth-rate of selected chanks released in Johanath par.

The three chanks bearing Tag Nos. Q. 71, Q. 87 and Q.77 in Table I were released in Johanath par. There is striking similarly here in the rate of growth of length and diameter.

TABLE V.

Serial number.	*Tag number.*	*Increase in length.*	*Increase in diameter.* MM.	*Period of growth days.*
(1)	(2)	(3)	(4)	(5)
1	Q. 71	8	6	382
2	Q. 87	8	6	427
3	Q. 77	16	12	456
Total ..	..	32	24	1,265
Average ..	..	10·6	8	421
Average in one year.	..	9·2	7	365

Chanks Nos. Q. 71 and Q. 87 show 6 mm. in growth in diameter after a period of 382 and 427 days in the sea respectively. Similarly the length shows 8 mm. growth in the above periods. Chank No. Q. 87 does not show a higher rate of growth inspite of the fact it remained in the sea for a period of 45 days more than Chank No. Q. 71. Chank No. Q. 77 shows a very high growth of 12 mm. and 16 mm. in length and diameter not recorded by any of the sixteen chanks under study. Perhaps this chank is of a different sex from the other fifteen.

Average growth-rates in the two localities.

The average growth rates in the two localities when compared shows that the average rate of linear growth per year is 4·1 mm. for Thollayiram par and 9·2 mm. for Johanath par. That of diameter 6·1 mm. year in Thollayiram par and 7 mm. year in Johanath par. The later seems to be a more favourable locality for the growth of chanks as revealed by the observations made so far.

Migration.

Speculations about the migration of Chanks has been very wide in the past. It is said that chanks migrated from Indian side to Ceylon side and *vice versa*. This speculation can be confirmed only if our marked chanks are recorded from the Ceylon Chank beds. So far no such record has come to our notice.

From data gathered in the present study shown in Table VI below, the chanks released in Thollayiram par area migrated towards North and South. In the North they migrated to Johanath par, Siluvai par and Athomathu par. In the South they migrated to Kodamuthu par, Melombathu par and Vadaombathu par. Two chanks did not show any migration.

TABLE VI.

Serial number. (1)	*Tag number.* (2)	*Place of release.* (3)	*Place of recovery.* (4)
1	Q. 404	Thollayiram par	Melombathu par
2	Q. 346	Do.	Siluvai par.
3	Q. 256	Do.	Kodamuthi par.
4	Q. 330	Do.	Do.
5	Q. 213	Do.	Melombathu par.
6	Q. 226	Do.	Siluvai par.
7	Q. 364	Do.	Johanath par.
8	Q. 362	Do.	Siluvai par.
9	Q. 361	Do.	Melombathu par.
10	Q. 201	Do.	Johanath par.
11	Q. 205	Do.	Kodamuthu par.
12	Q. 437	Do.	Thollayiram par.
13	Q. 406	Do	Athombathu par
14	Q. 71	Johanath par	Do.
15	Q 87	Do.	Thollayiram par.
16	Q. 77	Do.	Vadaombathu par.

The lines of migration are only hypothetical and it is not necessary that the chanks should have adopted a straight line of migration. They might have adopted a round about route or a zig-zag route. Hence the distance actually migrated is difficult for calculation.

Economic bearing of the problem.

Leaving aside the scientific interest of the problem, the practical application of the study to the artificial cultural operations of chanks should be the ultimate object of such a study. That a beginning has been made in this towards this ultimate object in view is a matter of satisfaction. People interested in the commercial exploitation of chanks will continue to ask the question " how long will it take for a chank to attain the required size for commercial exploitation ". The preliminary investigations have shown that the chanks differ in their rate of growth depending upon the season and environmental factors and that there is no relationship between growth rate in length and growth rate in diameter. The growth rate shows higher at Johanath par and lower at Thollayiram par from where the chanks were recovered. If this fact could be confirmed by further observations, then it will be possible to transplant on a large scale chanks from one locality where the growth rate is poor to another where the growth rate is higher, thereby increasing the productivity of the bed.

References.

Chidambaram and Unny, 1947. " Certain observations on the development of Sacred Chank.

Zancuspyrun (Linn) Proc. Zoo. Soc. Volume 117, Parts II and III, pp., 528, 532.

Devanesen, D. W. and Chacko, P. I. 1944. " On the bionomics of the Sacred Chank, Xancuspyrum (Linn) Proc. nat. Inst. Sci., India.

Hornell, J. 1914 .. .. " The Sacred Chank of India. Madras Fisheries. Bull 111.

.... 1916 .. " The Indian varieties and races of the genus Turbinella. Mem. Ind. Mus. 6. 109.

.... 1914 .. " On the occurence of the Sinistral form in shells of the Sacred Indian Chank " Turbenella pyrum " (Linn) with preliminary note on the chief local races. Extrait due IX Congress international De Zoologie. Tenu a Monaco.

Moses, S. T. 1922 .. " The anatomy of the Chank (Turbinellapyrum) Madras Fish. Bull. 17. 105.

Rao, K V. and Nair. K. N. 1956 " Rate of growth in spat and yearlings of the Indian Back Wateroyster, Oysteren Madras Sensis. Preston, Ind Jour Fish. Volume 3, pp. 231-260.

STATISTICAL STUDIES ON THE COMMERCIAL CATCHES OF CHANKS FISHED OFF TUTICORIN, GULF OF MANNAR IN 1962–63

By

P. S. SAMBANDA MURTHY AND P. I. CHACKO.

A Statistical analysis of the Chanks fished off Tuticorin in the year 1955 was given by Chacko and Palani (1959). A similar note on the chanks obtained during the 1962-63 season (7th December 1962 to 20th May 1963) is given here. The catch per unit effort and the percentage of worming in the different Chank beds are also reported. For understanding the working of the Chank Fishery and of the terms full-sized, under-sized and wormed chanks reference may be made to the brief account of chank fisheries of Tuticorin, given by Chacko and Rajendran (1956).

From Table I it may be seen that there was a total number of 114 days of actual diving operations. The average number of divers engaged in the operations per day worked out to 254. The total number of Chanks fished were 592,967 out of which 440,747 full-sized chanks were paid at the rates of 47 Paise each and 110,858 wormed Chanks were paid for at the rate of 3 Paise each and 41,362 under-sized chanks were confiscated to the Government. The average number of full-sized chanks fished per diver was 15 as in 1955.

From Table II it may be seen that the catch per unit effort varied from one bed to another and the maximum was 74 per diver recorded in Kanava Kadayan par and the minimum was 10 recorded in Karai par. The average catch per unit effort comprising all the three categories of full-sized, wormed and under-sized chanks worked out to 20 chanks.

The percentage of worming in the different chank beds also shows variance from one bed to another. The maximum worming was 43 per cent noticed in Kilathi par and the minimum was 13 per cent noticed in Vadavambathu, Janath and Thollayiram pars. The average working of chanks in the different beds worked out to 18 per cent.

Reference.

1. Chacko, P. I. and Palani, E. (1959)—A Statistical Analysis of the Chank Fishery off Tuticorin, Gulf of Mannar in 1955. *Madras Fisheries Station Reports and Year Book* 1955-56, pp. 206-207.

2. Chacko, P. I. and Rajendran, A. D. I. (1956)—A survey of the fishing industry of Tuticorin, Gulf of Mannar. *ibid.* 1954-55, pp. 177-193.

TABLE I—SHOWING STATISTICS OF CHANKS.

Fished off Tuticorin in 1962–63.

Serial number and name of Chank bed. (1)	*Number of days of diving.* (2)	*Total number of divers.* (3)	*Number of Chanks fished.* *Full-sized.* (4)	*Wormed.* (5)	*Under-sized.* (6)	*Total.* (7)
1 Vadaithundan	11	3,260	55,845	15,590	4,541	75,976
2 Kolikujuthavu	5	290	4,742	1,268	311	6,321
3 Melakeluthi	5	1,552	20,303	5,663	1,949	27,915
4 Saithukeluthi	2	785	8,006	1,368	592	9,966
5 Siluvai	19	5,966	91,027	28,227	7,752	127,006
6 Aluva	1	436	6,576	1,646	531	8,753
7 Melombathu	15	4,406	65,169	12,850	7,799	85,818
8 Vadavambathu	4	941	10,957	1,829	876	13,662
9 Janath	7	1,304	18,694	3,162	1,780	23,636
10 Thollayiram	4	1.235	13.788	2.390	1,815	17,993
11 Saithombathu	2	430	4,283	817	359	5,459
12 Kodamuthi	5	1.648	19,217	4,751	1,802	25,770
13 Poonthottam Nadumalai	2	483	21,730	6,495	2.237	30,462
14 Kadayan	6	431	3,189	1,712	337	5,238
15 Pasi	2	312	4,856	913	571	6 340
16 Kanava Kadayan	1	172	10,064	1,801	798	12,663
17 Vaipar	2	413	10,021	2,380	761	13,162
18 Athumabthu	14	3,952	52,576	3,141	5,202	71,919
19 Kilathi	1	31	224	194	32	450

TABLE I.—SHOWING STATISTICS OF CHANKS *cont.*

Fished off Tuticorin in 1962–63—*cont.*

Serial number and name of Chank bed.	*Number of days of diving.*	*Total number of divings.*	*Number of Chanks Fished.*			
			Full sized.	*Wormed.*	*Under sized.*	*Total.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
20 Karai	1	108	665	371	69	1,105
21 Patharai	1	6	43	20	5	68
22 North Siluvai	1	179	3,066	773	236	4,075
23 Kuthukudipidikka	1	219	5,335	1,230	346	6,911
24 Kattuthirukkai	1	235	6,050	1,402	390	7,842
25 Nagarai	1	198	3,321	865	271	4,457
	114	28,992	4,40,747	1,10,858	41,362	5,92,967

NOTE.—The Chank beds are referred to the nearest Pearl bank as there are no specific names assigned to the Chank beds.

TABLE II—SHOWING THE CATCH PER UNIT EFFORT AND THE PERCENTAGE OF WORMING IN THE DIFFERENT CHANK BEDS FISHED OFF TUTICORIN IN 1962–63.

Serial number.	*Total catches.*	*Total divers.*	*Catch per unit effort.*	*Wormed.*	*Percentage of worming.*
(1)	(2)	(3)	(4)	(5)	(6)
1	75,976	3,260	23	15,590	20
2	6,321	290	22	1,268	20
3	27,915	1,552	18	5,663	20
4	125,006	5,966	21	28,327	22
5	9,966	785	13	1,368	14
6	8,753	436	20	1,646	19
7	85,818	4.406	19	12,850	15
8	13,662	941	14	1,829	13
9	23,636	1,304	18	3,162	13
10	17,993	1,235	15	2.390	13
11	5,459	430	13	817	15
12	25,770	1,645	16	4,751	18
13	30,462	483	63	6,495	21
14	5,238	431	12	1,712	35
15	6,340	312	20	913	14
16	12,663	172	74	1,801	14
17	13,162	413	32	2.380	18
18	71,919	3,952	18	13,141	18
19	430	31	14	194	43
20	1,105	108	10	371	33
21	68	6	11	20	29
22	4,075	179	23	773	19
23	6,911	219	31	1,230	18
24	7,842	235	33	1,402	18
25	4,457	198	22	865	19

PHYTOPLANKTON OF BHAVANISAGAR RESERVOIR

T. FRANKLIN,

Hydrology Laboratory, Madras-10.

Introduction.

Very few accounts are available about the plankton of tropical impoundments. These "river lakes" differ both from the fluviatile rivers and the static lakes. The distribution and variations in the phytoplankton are therefore of interest. Sreenivasan *et al* (1954) have enumerated the seasonal abundance of some major taxa of phytoplankton in this reservoir but the detail species indentification was not made. In this paper a description of important species is furnished.

Materials and methods.

Plankton samples were collected by making vertical hauls at each depth whenever physical and chemical observations were made. The standard net used made of silk bolting cloth of 120 meshes per square inch.

The plankton were also collected by water sampler (Nansen's water bottle) at different depths. The capacity of the bottle is 1,200 c.c. This was transferred into a wide mouthed stoppered jar. To this, 50 c.c. to 80 c.c. of Lugal's iodone was added to settle and preserve the phytoplankton population. This method is satisfactory to study micro-plankton which escape the net. It is rather difficult to collect zooplankton with water sampler as there is a tendency for this macro-organisms to escape before they are trapped. By towing the net it is possible to collect zooplankton too.

The planktonic organisms are one of the most important elements in the economy of a reservoir but rather difficult to evaluate. It has been measured volumetrically and numerically by Sedgewick rafter counting chamber. The volumetric method is relatively rapid, but does not permit analysis of the components of the plankton. Plankton is studied as a mass and not as an association of organisms. The volumetric method also has the well known difficulty arising from the fact that different planktons settle of centrifuge at different rates. By enumerating the different organisms it is possible to compare their relative abundance in different places and to determine this seasonal variation of individual species.

Description of the phyto plankton species :— Chlorophyceae.

1. *Pediastrum Boryanum (Turp) Menegh (Lemmermann) Brunnthaler and Pascher f. (Prescott) Smith f. Fig. No. 1.*—Coenobe unperforated, peripheral cells bilobed ; the species of the lobes extending into narrow process ; surface punctate ; number of cells in the coenobium vary. Exceedingly common throughout regions wherever quiescent conditions exists.

2. *Pediastrum simplex* v. *duodenarium (Bail) Rab. (Prescottf) Smith f : Fig. No. 2.*—The variety apparently differs from the typical in the reticulate arrangement of the inner cells. Common throughout region in quiet waters.

3. *Coelastrum microporum Naeg. (Lemmermann Brunnthaler and Pascher f (Prescott) Smith.*—The colonies of this species are spherical as are the cells, cells lack surface projections. Diameter of cells 6 to 27 .

4. *Selanastrum westii G. M. Smith (Prescott f) Smith :* 1920.—Cells arcuate, curved only to about half circular rather than into a horseshoe as it is a characteristic of other species like Selanastrum Bibraianum, Reinsch, Selanastrum gracile Reinsch, Selanostrum minutum. Poles pointed Length 15-18 u. width 5 u. The cells of Scenedesmus are side by side although on a curved axis, rather than back to back as in common in this genus. The difference is not always a distinct one, since a strong curvature of the Scenedesmus colonies brings the cells almost back to back and many aggregations are irregular so that the arrangement is uncertain.

5. *Scenedesmus quadricauda (Turp) (Lemmemann Brunnthaler) and (Pascher f) (Prescott Smith f).*—Cells oblong or oval with broadly rounded poles ; flat plate colonies of four cells ; outside cells have one spine at each pole. Cell 11-16 u. length and 3-5 u. width. Spines length 10-12 u.

6. *Cosmarium subspeciosum* v. *validus Nordst. (Irenee Marie. f) (Nordst) (Prescott I).*—It is larger in size and the slightly greater number of row of granules (seven or eight) in the mid region of the face length 65-85 u. width 47-62 u.

7. *Staurastrum gracile Ralfs (Irenea-Marie f) (Nordsteadt (Prescott).*—Vertical view of cells traiangular with arms about as long as the body

section lateral margin with a line of small linear ridges along each edge; arms extending laterally, extending into 4-5 sharp points, ringed with several circles of granules margin slightly undulate; body of the semicells inverted trapezoid in side view. Length 27 to 107 μ. width 44-188 .

8. *Euastrum verrucosum Shr (Irenee-Marief) (Nordstedt) (Prescott I).*—Semicells trapezoid, apical notch wide and shallow two lateral lobes on each side, lower lateral sinus wide and shallow, upper narrower, deeper all lobes surmounted by groups of granules; face of cells with three concentrically arranged rows of granule group just above the sinus center group being largest. Entire surface covered with very small granules. Length 88-144 μ. width 68-108 μ.

9. *Tetrastrum staurogeniaeforme: (Shored) Lemm, (Lemmermann Brunnthaler) and Pascher Prescott, Smith).*—Colonies of four quadrately arranged cells; Cells flat on inner surface and convex on the outer; five rather short setae of about equal length present Diameter of cells 5-6 μ.

10: *Ankistrodesmus falcatus (Corda), Ralfs (Lemmermann Brunnthaler) Pascher, f. Prescott f. (Smith).*—The cells narrowly spindle-shaped to needle-shaped or sigmoid Chloroplast a single parietal plate, or it may be devided into two both single cells and bundles are formed in the species proper. Length is, about 150 μ. and width of 5 μ.

11. *Mesotaenium macrococcum Roy (Kuetz) (Nordstedt) (Prescott).*—Cells oval or cylinderic oval in out line, terrestrial embedded in jelley; chloroplast laminate; Length is 22 to 38 μ. and width of 11-20 .

12. *Botrycoccus Braunii Kuetz (Prescott) Smith.*—Cells more or less spherical, except that the mutal compression of the cells causes most of them to be ovoid or wedge-shaped; cells bunched together in large number in Characteristic irregular colonies; sorrounded by a dense wrinkled orange brown jelly, diameter of cells about 3 to 6 μ.

13. *Peridinium cinctum Ehr. (Prescottb) (Schilling).*—Cells spherical or oval in shape, epicone slightly larger than hypocone transverse furrow broad, lipped on the both margins, descending to the left about width of furrow, longitudinally narrow extending a short way into upper part and to lower apex; plates quiute distinctly areolate sutures between them wide and transversely straited. Length is equal to width 45 to 60 .

14. *Ceratium hirudinella (O.F.M.) Schrank (Prescott) Smith.*—The asymmetry and long horns of the cells distinguished this dinoflagellate; the anterior valve (epicone) is extended into a single very large horn and there are three shorter stouter horns in the posterior valve (hypocone). The ornamentation is usually easily discernible, the plates being areolate (with holes or compartments) the margins of the plates with many short, sharp points. Length is about 95 to 400 μ. Available in the month of February, March, May and July.

15. *Crucigenia quadrata Morren (Lemmermann, Brunnthaler and Pascher f) (Smith).*—Cells approximately ninety degree sectors flattened by mutal compression on their inner surface and rounded on their outer; no apprandages or projections in the outer, free walls. Cells length is 3 to 7 μ. and width 5 to 6 μ.

16. *Chodatella Lammeramann* 1898 *(Lagerhaimia of Smith 1933 Prescott), etc.*—The solitary cells of this genus all have a limited number of *setae* arranged at the poles and never at the mid section. The shape of the cells is variable, being oval, elliptic, subcylindrical or subspherical. *Chodatella Chodatii* Born (Lommermann, Brunnthaler and Pascher) (Smith). This species has subspherical cells with four spines cruciately arranged. Diameter about 5 to 16 μ.

17. *Closterium lanceolatum Kuetz (Irenee-Marie) (Nordstedt) (Prescott).*—Cells arculate, slightly curved, tapering to rather sharp apicies; Chloroplast ridged containing a row of 6-7 pyrenoids in each semi-cells. It has wide distribution in fresh water bodies.

18. *Pleurotaenium Ehrenbergi (Breb) De Bary (Irennea-Marie) (Nordstedt) (Prescott).*—Cells elongated, cylindrical, tapering slightly to truncate apices which are decorated with a circle of 8-9 tubercles; constriction at mid region slight; two distinct undulation at base of the semicells and slight ones often present beyond these; Chloroplast shaped as longitudinal bands with small pyrenoids scattered through them.

19. *Euglena virdis Ehr.*—Cells usually free swimming or crawling fusiform to elongate cylindrical, usually very metabolic. Flagellum one of varying length. Periplast usually distinct striate-chloroplasts band shaped, recticulate or discoid with or without pyrenoids. Paramylum long rods disc and also sheathing pyrenoids in some species. Green colour often masked by haematochrome.

20. *Mougeotia genuflexu (Dillo) C. A. Agardh.*—Most species have a relatively wide, band shaped chloroplast containing a row of large pyrenoids. The chloroplast (axial) is capable of rotating within the cells so that the band, when seen an edge, appears as a narrow ribbon. The shifting of the chloroplast is supposed to be a response to the direction of more favourable illumination.

21. *Eudorina elegans Ehr.*—In this species the cells have a tendency to arrange themselves in transverse bands or tiers occurs along with volvox colonies and Pleudorina.

22. *Chlorococcum humicola (Naeg) Rab.*—Cells occasionally are seen to be in closed in a mucilaginous sheath, Chlorococcum humicola is probably the most widely distributed, algal species in the World.

23. *Oedogonium sp.*—There are over 250 species in this large genus which belongs to a family (Oedogoniaceae) in which there are only two other genera (Bulbochaete oedocladium). Oedogonium plants begin as attached filaments and may remain so throughout life, or they may become free floating and form cottony masses near the surface. Usually becoming pale yellow green or cream coloured.

II. *Bacillriophyceae.*

1. *Nitzschia palea (Kutez) W. Smith (Fig. No. 1) (Syn. Synedra palea Kuetz).*—Valves linear 30-50 µ. long, 3 to 5 µ wide with ends narrowing to the hardly subrostrate to subcapitate poles transverse striate very fine.

2. *Nitzschia subtilis (Kutezing) Gronow (Syn. Synedra Subtilis Kuetz).*—Valves linear-lanceolate 90-130 µ. long and 3-5 µ. wide, evenly narrowed to the almost acute poles; keel extentric.

3. *Navicula longicephala Hust.*—This is common in fresh water. The two ends are elongated and broader in the middle. The striate are parallel and opposite to each other. The raphe is straight.

4. *Navicula gracilis.*—This is more or less measuring 20 to 30 µ in length. It has the distinct chloroplast and striation are not distinct.

5. *Synedra ulna Ehrehberg.*—Dominant in the reservoir waters in early summer. Variable in length. Dimensions 144 to 450 µ. long.

6. *Melosira dubia Kuetzing Kieselal.*—The valves show irregular decussating lines of fine punta. Dimensions 18 to 20 µ. in diameter.

7. *Cyclotella striata (Kuetzing) Gronow (Syn. Coscinodiscus striatus Kuetzing).*—Cells 25 to 30 µ in diametre outer zone broad with well marked stride. Every second or third striate marked with a prominent pore; sometimes very short or fine marginal striate in between the long ones at deeper focus submarginal curves often visible between the pores inner zone with irregular swellings.

8. *Gomphonema elegans Grun.*—The form is zygomorphic. Gomphonema has only single often deeply incised Chromatophore the median portion of which lies against one of the girdles, while the rest spreads over on to the valve faces. The commonly available species are gomphonema elegans Gruna.

9. *Amphora ovalis, Kuetzing, Hustedt Bac., 342, Fig. No. 628.*—Amphora ovalis Kg and its varieties occurred in all Collections.

10. *Fragillaria vaucheriae (Kuetzing) Boye Peterson (Syn. Synedra vaucheriae Kuetz., f. intermedia Gronow).*—Cells 50 to 90 µ. long and 3 to 6 µ. wide forming closely knit ribbons; girdle view linear rectangular valve view elongate-lanceolate narrow and near the ends. Capitate pseudoraphe narrow transverse striate marked 9-12 in 10 µ. with clear central area on one side.

11. *Pinnularia virdis (Nitzshi) Ehr.*—Frustules are symmetrical. The valve are usually with rounded poles and straight parallel sides. As seen in the girdle view the frustules are rectangular with smooth girdles and without intercalary bands within a cell one, two laminate chromatophore, generally with pyrenoids that on opposite sides of the girdle.

12. *Cymbella lanceolata (Enhernberg) Van Heurck.*—(Syn. Coconema lanceolata Ehrenberg) Valves distincly asymetrical naviculoid 70 to 80 µ long and 15 to 20 µ. wide with a convex dorsal margin slightly towards the middle; Striate at right angles to the raphe in the middle; radial at the poles 7-11 . in 10 µ. markedly punctate.

13. *Cascinodiscus dividus Grunow.*—Cells 30-50 . in diameter valves flat arcolate small. The valves are commonly circular in out line and the cell membrane as a whole can be likened to a circular box.

14. *Stephanodiscus biserialis.*—Cells drum shaped, valve circular 40-50 µ. in diameter hallowed in the middle striate in two series, the outer series finally punctate 11-12 in 10 µ.

III. *Cynophyceae Blue Green Algae.*

1. *Microcystis aeruginosa Kuetzing of Geiiler Daily* 1952.—Cells spherical, clustered in a clearly discernible gelatinous matrix the outline of which may be spherical and solid or irregular in shape and somewhat perforated; Cell contents blue-green with conspicious psuedovacuoles. Diameter 3-6 rarely 2-10 .

2. *Oscillatoria formosa Bory (Geitlar b) (Prescott).*—Trichomes straight or flexuous, usually slightly constricted at the cross walls, briefly tapered, bent or hooked towards conical apical cells, cell contents bright blue green transferse cell walls sometimes finely granulate; cells quadrate or shorter cells length 2 to 5 . width 4-6 .

3. *Spirulina major Kuetz (Prescott) (Smith).*—The regular corkscrew shape of the trichomes distinguishes the genus from others in the family. There is no distinct cross walls in the spirulina and in some species they have been demonstrated by staining.

Spirals of trichomes loose, regular cells width 5-1-75 μ. spirals length 2·75 μ. width 2-5-4 μ.

4. *Anabaena flos-aquae (Lyng b) Breb (Geitlarf) (Prescott f).*—Trichomes usually curved, united in the bundle cells barrel shaped of compressed spherical hetrocystic slightly larger than vegetative cells shaped similarly spores next to or remote from heterocysts. Cylindrical with rounded ends curved oblique in equilateral with smooth colourless or yellowish wall. Cells length 6-8 μ., width 4-8 μ., spores length 20-50 μ. and width 7-13 μ.

5. *Merismopedia tranquilla (Ehr) Trev.*—Cells are spherical or oval devide in two planes at right angles so as to form flat plates with regular rows in a rectilinear arrangement. This species is generally smaller in size 2-64 cells. Cells spherical or oval contents smooth or granular blue green. Diameter 1-4

6. *Microcoleus vaginatus (Vauch) (Geitlar f) (Prescott) (Smith).*—Trichomes unconstricted at cross walls numerous; parallel within sheath; very gradually attenuate to ends; Capitate at apex; cell contents blue green, to olive green, cross walls usually granulated length of the cell 3-7 μ. width 2-3 .

7. *Holopedium irregulare leg.*—This genus differs from Merismopedia by having the cells irregularly arranged within a gelatinous plate.

8. *Aphanocapsa grevillei (Hass) Rab p.A.ela christa West and West.*—Cells distributed throughout the colonial mucilage whereas microcystis has cells compactly arranged in this genus they are rather evenly spaced throughout the colonial mucilage. The cells are spherical and vary in size in different species. Cells often appear in pairs.

9. *Aphanizomenon flos-aquae (L) Ralfs (Prescott) (Smith).*—Colonies in thin spindle like floating bundles made up of short straight trichomes tapering slightly at the ends, cells more or less quadrata cylindrical; heterocystis one in each trichomes approximately cylindrical or slightly tumid.

10. *Tetrapedia, Sp.*—The Cells are rectangular and approximately square on this flat side. The four corners of the rectangular cells are moderately curved, each of them bearing a small hyaline spine. The surface of the cells is not a complete plane but shows four bulges, one at each corner reaching their highest point at the position where they would lie above the oblique diagonals and slopping gently towards the points of the triangular constrictions of the walls, and towards the center of the cell. From the side view the cells have a broad oval shape. The diameter of the cells varies between 2 to 5 . This width is between 1 to 3 μ. The nucleus is a small, compact body is located at the arthemetical centre of the cell Propagation occurs with the formation of autospores.

Acknowledgments.

I am deeply grateful to Thiru A. Sreenivasan, Assistant Director of Fisheries (Hydrology), Madras for his guidance and kind help in writing this account.

Reference cited.

1. Claus, G.—Comments on the species of the genus Tetrapedia Reinsch (Chroococcaceae cyanophyta), " Hydrobiologia "—Vol. XXI, 1st May 1963, No. 3-4.

2. Fritsch, F. E.—" The structure and Reproduction of the Algae ", Vol. I—Cambridge at the University Press, 1956.

3. Smith Gilbert, M.—" Manual of Phycology "—Valtham. MASS U.S.A. Chronica Botanica Company, 1951.

4. Smith Gilbert, M.—" Cryptogamic Botany ", Vol. I (Algae and Fungi) M. C. Graw. Hill. Book Company INC, New York, Tornto, London.

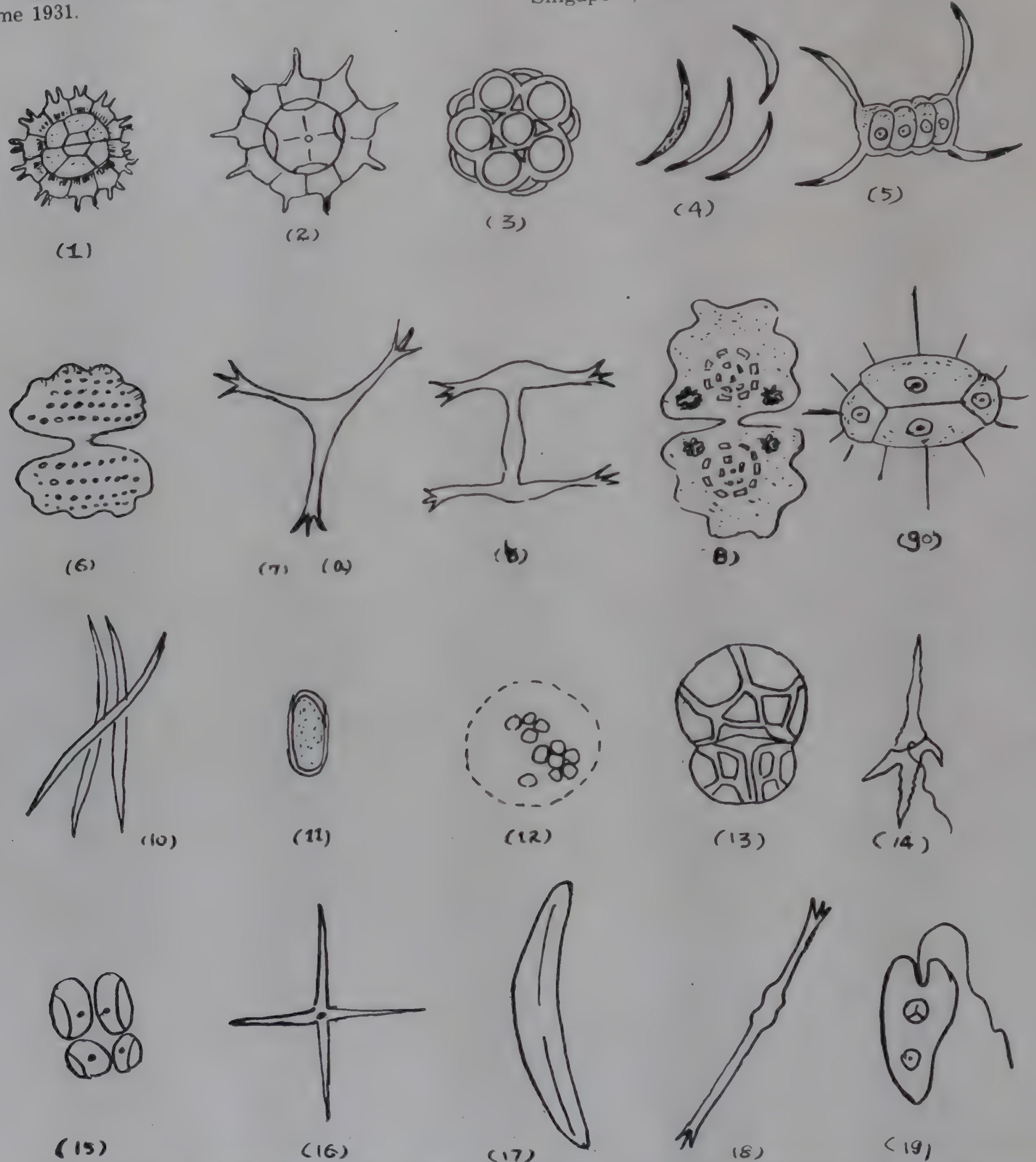
5. Herman Silva Forest—" Hand Book of Algae ". The University of Tinnessee Press—Knoxville. 1954.

6. Prescott, G. W.—" The Fresh water Algae " —W.M. C. Brown Company, Dubuque, IOWA.

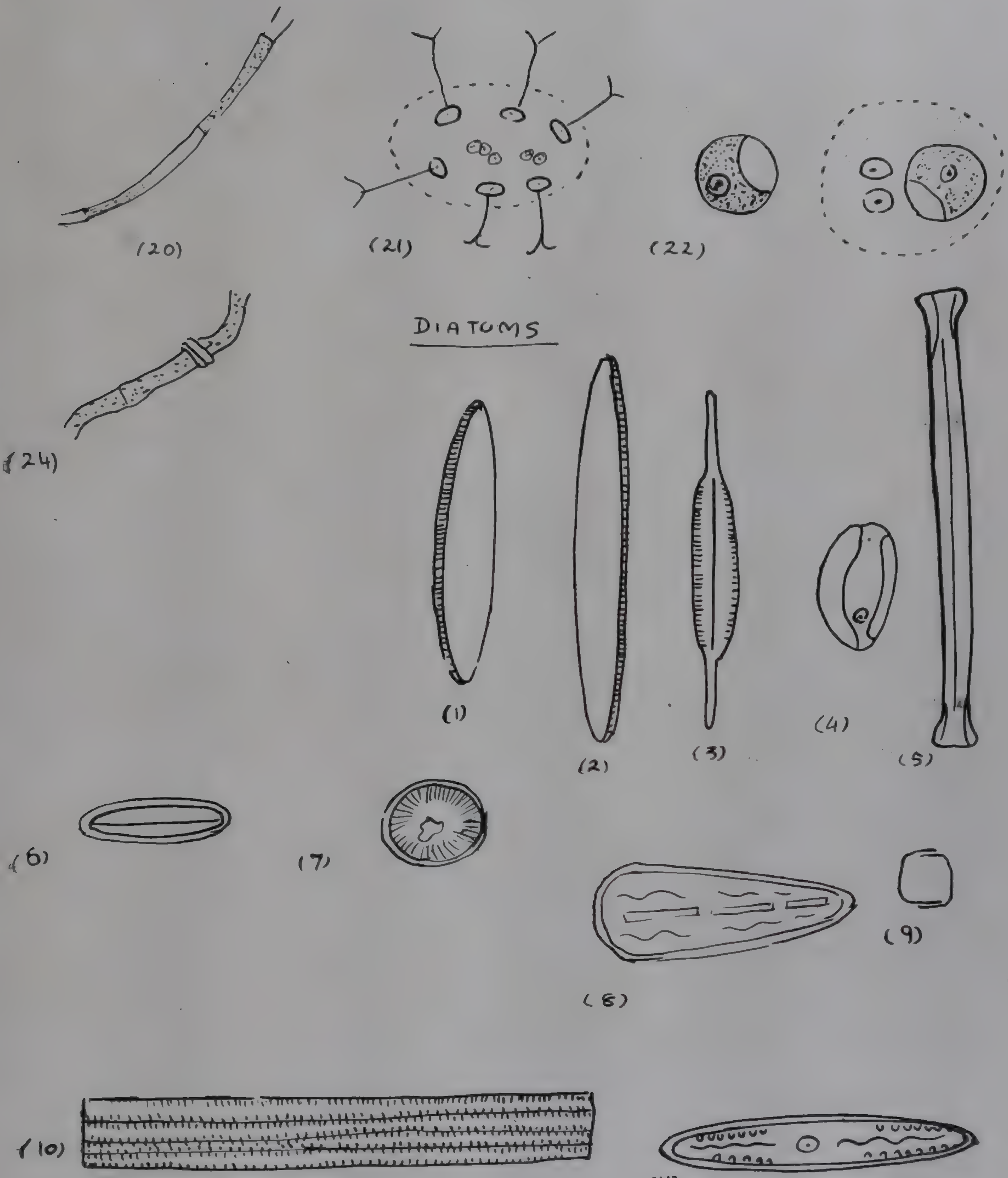
7. Ralph Hile and Will Scot—"Investigations of Indiana lakes"—2. The rate of growth of Fisheries of Indiana. 3. The lakes of North Eastern Indiana. The department of Conservation State of Indiana. The division of Fisheries Game 1931.

8. Hurry Baldwin Ward George Chandler Whipple—Freshwater Biology. Second Edition. New York, London. Johu Wiley and INC.

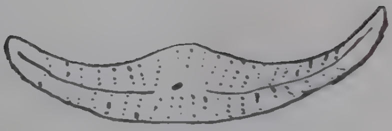
9. G. A. Prowse—"Diatoms of Malayan Fresh Water"—Reprint from the gardens Bulletin. Singapore, Vol. XIX, Part 1, 15th 1962.

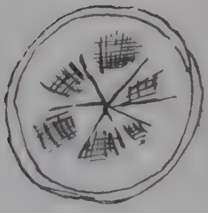


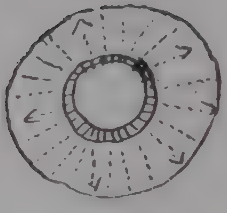
I Chlorophyceae : (1) Pediastrum Boryanum. (2) Pediastrum simple. (3) Coelastrum microporum. 4. Selanastrum westii. (5) Scenedesmus quadricauda. (6) Cosmarium subspeciosum v. validis Nordst. (7) Staurastrum gracile Ralfs. (a) vertical view. (b) side view. (8) Euastrum verrucosum Ehr. (9) Tetrastrum staurogeniae forms. (10) Ankistrodesmus falculatus. (11) Mesotaenium macrococcum. (12) Botrycoccus Braunii Kuetz. (13) Peridinium cinctum Ehr. (14) Ceratum hirudinella (O.F.M.) Schrank. (15) Crucigenia quadrata. (16) Chodatella Chodatti Born. (17) Closterium lanceolatum Kuetz. (18) Pleurotaenium Eherenhergii. (19) Euglena virdus Ehr.



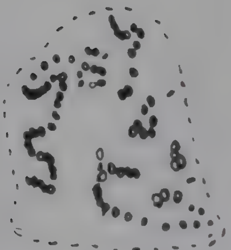
(20) Mougeotia genuflexa (Dillw). (21) Eudorina elegans Ehr. (22) Chlorococcum humicola (Naug) Rab. (23) Oedogonium sp. DIATOMS—(1) Nitzschia palea. (2) Nitzschia subtilis. (3) Naviculalongicephala Hust. (4) Navicula gracilis. (5) Synedra ulna Eherenberg. (6) Melosira dubia. (7) Cyclotella striata. (8) Gomphonema elegans. (9) Amphora ovalis. (10) Fragillaria vaucheriae. (11) Pinnularia virdis (Nitzschii) Ehr.

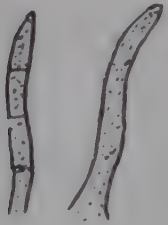

(12)

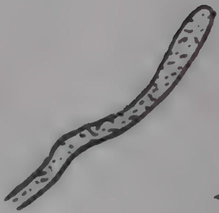

(13)

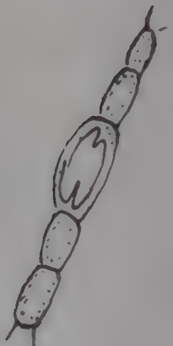

(14)

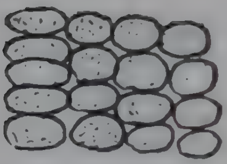
CYNOPHYCEAE

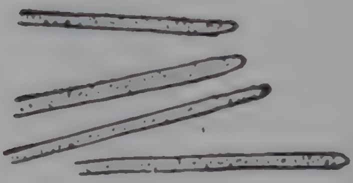

(1)

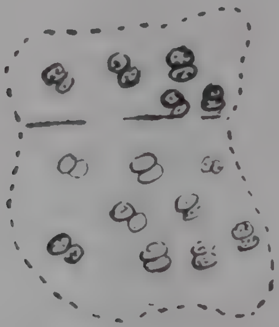

(2)

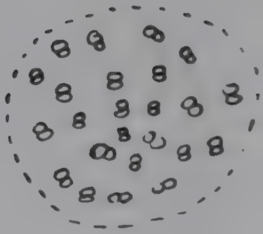

(3)

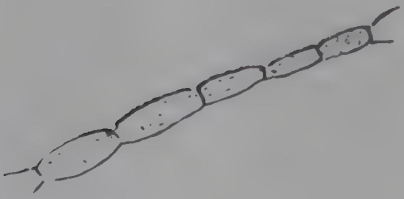

(4)

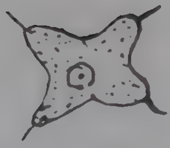

(5)


(6)


(7)


(8)


(9)


(10)

(12) Cymbella lanceolata (Eherenberg). (13) Coscinodiscus dividus gronow. (14) Stephanodiscus biserialis.

CYANOPHYCEAE—(1) Microcystis aeruginosa. (2) Oscillotoria formosa Bary. (3) Spirulinamajor Kuetz. (4) **Anabaena flos-aequae.** (5) Merismopeda tranquilla. (6) Microcoleus vaginatus. (7) Holopedium irregulare. (8) Aphanocapsa grevelli **(9) Aphanizomenon flos acquæ. (10) Tetrapedia sp.**

SURVEY OF FISHING GROUNDS IN THE INSHORE-WATERS OF BAY OF BENGAL NEAR MADRAS IN 1966–67.

BY

P. I. CHACKO, MOHAMMED SULTAN AND KANAKARAJ DAVID.

Introduction.

The experimental fishing operations with trawl gears of three different sizes with a single type of 32 feet stern trawl boat fitted with 51 h.p. Torpedo Engine were continued during the year and the results are discussed with particular reference to the fishing grounds explored and their potentialities, fish populations and catch-effort. The Survey was conducted in the area of about 100 square miles into the sea up to 20 fathoms contour lying between lat. 13·5' N/ Long 80 25'E and Lat. 13·25' N/Long 80·25' E/opposite Pulicat and Ennore. This area was divided into squares of 25 square miles, and the 4 squares 13·80-C3(b), 13·80-C2(a), 13·80-C2(b) and 13·80C1(a) have been surveyed. Data about total catches, their percentage composition and seasonal variations were gathered and tabulated. The sea-bed lying in between 5 to 20 fathoms contour has been found to be an ideal trawling ground without much interventions for fishing both by private and departmental boats. In this area, especially in the shallower portion, there are rich prawn grounds which can be reached within two hours by mechanised boats based in Madras.

Topography of the Coast Line from Madras to Pulicat.

From Madras Harbour, the coast tends North eastward for about $13^1/_2$ miles to the village of Ennore. Numerous buildings with their conspicuous roofings all along the coast from Madras to Ennore are prominently seen and the Motor Works 'Asok Leyland' with its white roofing is situated about 11 miles north-north-eastward of Madras Light House. Between the entrance to Ennore backwaters and the town of Pulicat, about 11 miles northwards, the coast is low sandy and backed by an extensive plain which is densely wooded near the beach. Pulicat stands on an Island at the southern end of Pulicat lake. A light is exhibited from masonry tower. A tall and prominent monument stands close northward of the Light House.

Method of Survey.

Systematic survey of each square was done by making a fixed course worked out with reference to the Adimralty Chart and also by taking guidance of conspicuous land bearings. Data such as soundings at the exact location in the square along with meteorological conditions prevailing during the time of fishing operations in the sea were gathered in correlation with particulars of the experimental fishing conducted in the area. Observations made in each square in relation to the fishing aspects by operating different type of gears and the results achieved both on the qualitative and quantitative fishing on various seasons throughout the year were also incorporated to the information about the fishing grounds and the explored areas were duly charted on special maps.

Crafts and Gear.

The survey fleet continued to be consisted of 4 numbers of 32 footer boats of stern trawl type boats, specifications of which were detailed in the report for 1965-66. During the year 1966-67 trawl nets of 55 feet, 60 feet and 70 feet were continuously operated and studied for their relative efficiencies (Table I). Though the data so far collected are not adequate to draw definite conclusions, they indicate the fisheries potentialities and their seasonal variations. The data obtained by operating boats of the Fishermens' Training Centre in the same area were also utilised for drawing inferences (Table II).

The relative efficiency of the trawl nets show that the catch-effort of the 60 feet four seam non-over-hang trawl net with the otter board of 45 inches by 25 inches weighing 100 lb. (45·5 kgs.) is comparatively efficient and more suited for the boat of 32 feet fitted with an engine of 51 h.p.

Discussions.

Comparative analysis of the data gathered (*Vide* Tables III and IV) the rise in the catches was evidently during the period from November to February. The catches start declining from March to April for two months and thereon again there is a gradual rise from May to October. By close observation of the data, one has to infer that during the onset of the North-East Monsoon by middle of October or beginning of November various phenomenal changes take place in the condition of the sea, particularly the wind and current, attributing sufficient reason to ensure the peak season for the availability of good catches in the shore region between 5 and 20 fathoms. Also, it is observed that during this season prawns appear in abundance along with other catches of fish in the area specially between latitudes 13·10'N to 13·18'N. The sea bed opposite to Ennore and Pulicat in depths between 5 to 20 fathoms are rich with prawns. Their abundance during the North-East Monsoon period is evidently due to their migration for breeding purposes. In this monsoon period the bars of both Ennore and Pulicat backwaters keep open and consequently there is regular tidal flow appearing throughout the months of November and December during which time the two important major species (*Penaeus indicus and Metapenaeus monoceros)* predominate the catches by their migration from the backwaters. These grounds particularly in the depth between 10 to 12 fathoms with clayee substratum appears to be optimum in conditions for the prawns to liberate their eggs during this breeding season. This ground is about 50 square miles in area running north to south at a stretch of 15 miles with an average width of 3 miles. The bottom is sandy from 5 to 10 fathoms, clayee from 10 to 15 fathoms and of admixture with mud and clay from 15 to 20 fathoms. In this region mechanised boats 30 to 32 feet in length with 30 to 65 h.p. engines are mostly engaged in trawl fishing with 55 feet to 80 feet non-over-hang four seam otter trawl nets. Few local fishermen also operate "Thuri valai", a primitive indigenous trawl net from catamarans. The catch-effort by stern trawl boats during the peak season for fish varies from 30 kg. to 100 kg. per hour, of which prawns alone form 15 to 30 per cent.

It has to be recorded here that the currents prevalent off the Coramandal Coast, particularly in the vicinity of Madras Coast, attribute a great reason for the eventual migration of fish towards the shore region. In January, the current sets South-Westward or north-westward at a rate of 1 to $1^1/_2$ knots, but is irregular. In February, the current is northward parallel with the coast at $1^1/_2$ knots. From March to May, it is northward 1 to 3 knots. During June it is variable but sometimes southward and weak. In July and August south-westward or against the wind at 2 to 3 knots at times. In September it is south and south-west and strong. In October, southerly along the coast and strong; in November and December south westerly and southerly along the coast. From these details regarding the flow of currents during the monsoon season from October to December, the flow happens to be mostly southerly in direction along the coast with a strong nature. It is to be observed that the migration of fish also appears to be shore-ward. As the general tendency of fish is always to swim against the current, it is evident to infer that the flow of coastal current during October to December enrich the coastal area within the 20 fathoms belt with varieties of fishes. The reason for the decline of catches during March and April is the unsteady flow of current with a very mild trend of $1^1/_2$ knots which vary and is irregular in directions up to July.

In the east coast, though there are no major occurrence of any shoaling fishes like sardines and mackerels, the following order of fishes form to be more commercially important along the coast and are recorded in the catches of trawl nets.

1. Silver bellies.
2. Jew fish.
3. Ribbon fish.
4. Goat fish.
5. Lizard fish.
6. Plough fish.
7. Rays.
8. Soles.
9. Sharks.
10. Pomfrets.
11. Seers.
12. Crabs.
13. Prawns.

TABLE I—SHOWING RELATIVE EFFICIENCY OF THE TRAWL NETS OPERATED BY THE SURVEY BOATS DURING 1966-67.

Month. (1)	*Number of hauls.* (2)	*Total hours of trawling.* (3)	*Quantity of fish caught kgs.* (4)	*Size of the net in feet.* (5)	*Catch effort kg. hour.* (6)
April 1966	32	35	319·5	55·5	9·1
	24	26½	144·5	60	5·4
May 1966	18	18	328·0	55·5	18·2
	29	29	361·0	60	12·4
June 1966	44	48½	1,168·0	55·5	23·9
	50	55	2,184·0	60	39·7
July 1966	71	102	4,015·0	55·5	39·3
	2	3	81·5	60	27·1
August 1966	21	26½	463·0	55·5	17·4
	15	21	1,273·0	60	60·6
September 1966 ..	3	4	106·0	55·5	26·5
	25	32½	748·0	60	22·3
October 1966	15	16	544·0	60	34·0
November 1966 ..	3	3	20·0	60	6·0
December 1966 ..	10	14	393·0	55·5	28·0
	30	42	1,495·0	60	35·5
	9	9	501·0	70	55·6
January 1967 ..	11	15	404·0	55·5	26·9
	8	11½	489·0	60	42·5
	20	29½	794·0	70	27·1
February 1967	35	52½	2,049·0	60	39·4
	22	31½	1,242·0	70	39·4
March 1967	10	15	247·0	60	16·4
	20	30	900·0	70	30·6

TABLE II—SHOWING DETAILS OF FISH-CATCHES BY THE BOATS OF THE FISHERIES TRAINING CENTRE, MALPAS, DURING 1966-67.

Month. (1)	*Boat size (feet), engine type and h.p.* (2)	*Trawl gear size in feet.* (3)	*Total hours of trawling.* (4)	*Total catch in kg.* (5)
April 1966	30, Bukh, 30 .. .. .. 30, Yanmar, 30	55 60	19½	434·00
May 1966	Do.	Do.	20	540·00
June 1966	Do.	Do.	66½	2,462·00
July 1966	Do.	Do.	62¾	3,553·50
August 1966	Do.	Do.	47	3,402·00
September 1966	Do.	Do.	32¼	619·00
October 1966	Do.	Do.	45¼	769·50
November 1966	30, Bukh, 30	55	33¼	574·50
	30, Yanmar, 30	60	28¾	898·50
	32, Torpedo, 67	70	13½	540·00
December 1966	30, Bukh, 30	55	40	1,450·00
	30, Yanmar, 30	60	40	528·00
	30, Torpedo, 67	70	36	1,880·00
January 1967	30, Bukh, 30	55	48¼	1,331·00
	30, Yanmar, 30	60	35½	939·00
	32, Torpedo, 67	70	28¾	1,223·00
February 1967	30, Bukh, 30	55	12¾	310·00
	30, Yanmar, 30	60	74¼	2,189·00
	32, Torpedo, 67	70	60¾	2,561·00
March 1967	30, Bukh, 30	55	11½	76·00
	30, Yanmar, 30	60	40¼	812·00
	32, Torpedo, 67	70	17¾	219·00

TABLE III—TABLE SHOWING DETAILS OF FISHING DATA AND CATCH EFFORT DURING 1966–67.

Serial number and fishing vessels.	Fishing days.	Fishing hours.	Weight of silver bellies in kgs.	Weight of jew fish in kgs.	Weight of goat fish in kgs.	Weight of prawns in kgs.	Weight of other fishes in kgs.	Total catch in kgs.	Sale proceeds.	Average catch effort, kg./hour.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
									RS. P.	
1 S.T.B. 3	6	15	89·0	15·0	284·0	6·0	132·0	526·0	295 30	35·0
2 S.T.B. 4 ..	90	271½	2,360·0	1,302·0	604·0	920·0	3,374·0	8,560·0	4,775 05	31·5
3 S.T.B. 5	25	67	483·0	157·0	441·0	30·0	607·0	1,718·0	964 01	25·6
4 S.T.B. 6	77	221½	2,120·0	919·0	1,631·0	302·0	2,481·0	7,453·0	3,908 90	33·6
Total 4 ...	198	575	5,012·0	2,493·0	2,960·0	1,258·0	6,594·0	8,257·0	9,943 26	..

TABLE IV—SHOWING PERCENTAGE COMPOSITION OF FISHES OBTAINED.

Month.	Total catch in kgs.	Percentage composition.											
		Silver bellies.	Jew fish.	Ribbon fish.	Goat fish.	Thumbil.	Plough.	Rays.	Sharks.	Soles.	Crabs.	Prawns.	Other miscellaneous varieties.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
April 1966	464	46	2	..	20	10	14	1·7	..	..	..	..	6·5
May 1966	671	52·3	20·1	2	1·3	..	..	..	..	..	1	14·8	8·5
June 1966 ..	3,178½	29·3	5	1	32	16·8	1	4·4	..	..	..	2	8·5
July 1966	3,024½	29	3·2	..	44	17	..	1·5	..	..	..	..	5·3
August 1966 ..	1,482	37	..	..	36·6	19·6	2	..	..	..	..	..	4·8
September 1966	884	49	3·2	..	8	8	2	12·2	..	..	..	14·6	3
October 1966 ..	554	53·3	9	10·8	..	4·6	6	3	..	..	2	3·7	5·6
November 1966	20	65	..	..	..	..	..	15	..	20	..	..	..
December 1966	1,996	12·6	33·6	9·6	..	2·8	0·9	1·6	..	3·4	7·5	16·8	11·2
January 1967	1,499	1·3	25·3	21·2	..	0·35	1·7	1·7	..	1·2	8·8	18·25	20·2
February 1967	3,291	25	24·4	16	..	3	4	2·7	..	1	..	10	13·9
March 1967	1,157	26	8	..	17	27	2	20	..	..	..	..	..

SURVEY OF INSHORE WATERS OF SOUTH ARCOT DISTRICT COAST IN 1966-67

By

P. I. CHACKO, M. V. NATARAJAN AND E. EDWIN JOSEPH.

The survey of the inshore waters of the South Arcot District coast was continued during the year for location of fishing grounds and for the demonstration of trawling to the local fishermen. Three mechanised boats of the stern trawler type (1) STB. 7, 32 feet, 50 H.P. Torpedo engine, (2) I.F.S. 5, 30 feet, 37 H.P. Ruston engine and (3) I.F.S. 6, 30 feet, 24·5 H.P. Ruston engine, were employed for the survey. The area surveyed is about 100 square miles, and lay between latitude 11° 25′ and 11° 47′ and longitude 79° 45' and 79° 55' with depth upto 10 fathoms. The bottom is clayee with admixture of sand; but rocky patches have been detected at 7, $8\frac{1}{2}$ and 9 fathoms off Chittrapettai, Thammanapettai, Periakkuppam, Iyyampettai and Sothikuppam. On the whole the surveyed ground, extending from the Pennar river-mouth in the north and coleroon river-mouth in the South, has been found suitable throughout the year, excepting during the peak period of the north-east monsoon. The trawl catches comprised of silver-bellies, ribbon fishes, sharks, rays, skates, soles, jew fishes, big-jawed jumper, hore-mackerels, eels, goat-fishes, lizard fishes and prawns. A significant feature is the detection of prawn resources, which now contribute to more than 10 per cent of the catches. The presence of several backwaters and estuaries of rivers like Pennar, Gadilam, Paravanar, Vellar and Coleroon which not only bring into the sea nutrients and detritus favourable for prawns but also provide brackishwater environment required for young prawns for their growth, is responsible for the occurrence of prawns in this region. As a result of this survey and demonstration work, a prawn trawling and processing industry has commenced at Cuddalore and Porto Novo. This is also facilitated by a small fishing harbour at Cuddalore and a landing jetty at Porto Novo and iceplants and cold stores at both the centres. Indications are that there is more scope for the development of the fishing industry in this area; and departmental efforts are being made towards this end.

A PRELIMINARY HYDROBIOLOGICAL SURVEY OF CERTAIN ESTUARIES IN THE CHINGLEPUT DISTRICT, MADRAS STATE.

By

Thirumathi GEMMA EVANGELINE, P. MOHANAKRISHNAN and Selvi K. R. SEETHALAKSHMI.

BRACKISHWATER FISH CULTURE RESEARCH STATION, ADYAR, MADRAS.

Introduction.

Chingleput District in Madras State with an area of 2993 square miles has a sea coast of 115 miles. The general shape of the coast line is 'S'. The tides in this shore rise and fall by 3 feet at Full and New Moon and 1 foot 9 inches at quarters. The height of the waves is 3 feet in fine weather and it rises to 12 to 14 feet during gales. The bottom of the sea upto one mile is loose sand.

This district has the following estuaries:—

1. Pulicat Lake which is 25 miles North to latitude Madras City and is situated in 13° 25′ North and longitude 80° 18′ East.

2. Ennore estuary which is about 10 miles North to Madras City.

3. Coovum estuary which is situated in the Madras City and enters the sea adjacent to the Madras Fort St. George.

4. Adyar estuary which is also situated in the Madras City about 3 miles south of the Coovum estuary.

5. Covelong estuary which is about 22 miles south of Madras City and is situated in latitude. 12° 46′, North, longitude 80° 18′ East.

6. Pudupattinam estuary which is 42 miles south of Madras City and is situated nearly in the latitude 12° 31′ North and longitude 80° 14′ East and

7. Palar estuary which is about 50 miles South of Madras City and is situated in the village called Kadalur.

The present study which was begun in August 1966 has been taken up with a view to survey the present position of the fishery of these estuaries and to find ways and means of developing the same. This paper includes a study of all the estuaries in Chingleput District except Pulicat Lake, Ennore backwaters and Adyar estuary in which survey was conducted during the period November 1966 to October 1967.

Description.

Based on their origin the Coovum, Pudupattinam and Palar estuaries can be classified as Drowned River Valleys as all these estuaries are formed by rivers, which are not perenial. In the case of the Covelong backwaters no river enters it and only flood water from surrounding areas flow into it. It has most probably been formed by the development of a barrier beach. As in the case of estuaries formed by the development of barrier beaches due to shore line emergence, Covelong estuary lies parallel to the shore while the other four estuaries lie more or less perpendicular to the shore line.

(a) Origin of the rivers.

1. *Coovum river.*—This river arises as the surplus waters of the Coovum tank in Kancheepuram taluk of Chingleput district. During its course it irrigates the lands in Kadambathur, Tinnanur and other villages in the neighbourhood, feeds the Chembrabakkam tank, again irrigates lands in Mayanabhu, Ayanbakam and other villages and then enters the Madras City. It enters the sea near Napier bridge between Madras Fort and the University buildings.

2. *Pudupattinam river.*—This starts as an over flow channel of a large tank called Neenda Madugu with an area of 647 acres near Chingleput town. In its course, it enters an irrigation tank in Ponvazhlainda Kallathur village. From there it flows through different villages being at times nearly 70 feet in width. At the end of this it joins the irrigation tank in Perumbudur, flows out and then joins a Public Works Department Tank at Periakkathipakkam. From here it branches into two, one going through Perambakkam, Kuttyperambakkam and Kalveli villages and the other going through Vellathur. Both these branches join again at Pudupattinam and enter into the estuary. At Pudupattinam the Buckingham Canal also passes through the estuary.

3. *Palar river.*—The Palar river arises in the Mysore state and after flowing through the Chittoor and North Arcot districts enters Chingleput district a few miles to the West of Kancheepuram. About 8 miles east of Kancheepuram, at a place called Thirumukkudal, it is joined by the Cheyyar river. The Vegavathi stream also joins Palar within Kancheepuram taluk. The river then flows in a South-easterly direction and joins the estuary at a village called Kadalur. The flow in this river is uncertain and subject to sudden and heavy floods.

Physical features of the estuaries.

1. *Coovum estuary.*—This is in connection with the sea only during a small part of the year as a sand bar of an approximate width of 200 feet and a height of two feet is formed by tidal action. During the period of survey, the bar opened in September 1966, and closed again during January 1967. The width at the mouth is 200 feet and continues to be so for a distance of two furlongs. It then spreads out into a large stretch of shallow water. This extends west ward as the main estuary. On the north side it extends as a narrow branch or creek which takes various curves and then joins the main estuary about 3 miles from the mouth, enclosing an island. The total water spread of this northern branch is nearly 4 acres. The sides of the estuary are found to slope gradually resulting in a shallow V-shaped basin. The depth of the estuary ranges from 2 to 8 feet and during low tides mud flats which are present along the Northern Bank are exposed. The difference between high water mark and low water mark within the estuary is approximately 3 feet and tidal effects are felt only within a distance of one mile. The bottom soil is of fine sand mixed with silt and is black in colour from the mouth to the upper reaches. There is very little vegetation along the margin. The Buckingham canal passes through, entering in at the north end and taking off on the South side about 4 furlongs from the mouth.

2. *Covelong estuary.*—This lies parallel to the shore to an approximate length of 15 miles and is separated from the sea by land of an average width of approximately 3/4th mile and is connected with sea at both extremities. Due to the development of a sand bar, connections with the sea are maintained at both ends only during part of the year. The width of the bar is nearly 400 feet to 500 feet at the North end and is 300 feet at the South end. The bar was observed to open at the North end in October 1966 and close in January 1967 and again open

In February 1967 and close by the end of March 1967. In the south end it was found to open during November 1966 and close by the end of January 1967. The estuary is shallow, and is more spread out at the North end, the width being nearly one mile. At the south end it is rather narrow in addition to being shallow. In the middle stretch, the estuary narrows down into a deep channel in summer. Two creeks are found to take off one on either side of the bar of the north end. The south side creek and the shallow margin of the parallel portion of the backwater in the north end are used as salt pans. The whole basin in general is 'V' shape. The bottom soil is sandy near the mouth and becomes clayey away from the mouth in the north end. In the south side creek hard granite rocks are present. At the south end the bottom soil near the mouth is sandy while further away it is an admixture of sand and clay instead. The depth of water in the north end, ranges from 3 feet to 16 feet and the effect of tides are felt up to a distance of 2 miles. The difference between high and low water mark is nearly 5 feet. In the south end, depth ranges from 4 feet to 9 feet and tidal effect is felt up to a distance of only one mile. The difference between high and low water marks within the estuary is nearly 3 feet. The margin of the estuary is devoid of any vegetation.

3. *Pudupattinam estuary.*—This estuary is cut off from the sea by a sand bar of 200 feet width, which was found to open during November 1966 and close by January 1967. The estuary is narrower at the mouth and then spreads out towards one side extensively. This water piece is shallow and assumes a 'V' shaped basin. The water spread is roughly 50 acres. The estuary lies perpendicular to the shore. The bottom soil is sandy to a great length and is formed of coarse sand at the mouth. The depth varies from 4 feet to 12 feet and tidal effect is felt up to one mile. The difference between high and low water mark is 4 feet.

4. *Palar estuary.*—This is the widest of the estuaries studied and has extensive shallow regions. At the shore the distance from one end to other end is nearly three miles. The estuary opens into the sea at three places, the central opening being the widest. This estuary encloses a number of small and large islands. Shallow regions alternate with the deep areas. From the mouth the water spread extends only upto a distance of 2 miles to 2½ miles. The bottom soil is completely sandy through out and in shallow regions more silt is present. The depth is 6 feet to 14 feet and tidal effect is felt throughout the estuary. The difference between high and low water mark is 6 feet. The bar was found to open during November 1966 and close by the end of June 1967. From the main river at about 4 miles from the mouth, a side branch arises on the south bank, which forms into another estuary about one mile from the main estuary. It is about half a mile in width and is separated from the sea by a sand bar. The two estuaries are connected together by the Buckingham canal.

Materials and Methods.

Hydrobiological studies were made at three stations in every estuary fixing the first station at the mouth and the succeeding two stations a mile apart from each other. In the case of Covelong estuary, samples were collected separately at both the North and South ends. Samples were collected at the mouth and one other station in the Pudupattinam estuary. Fishery statistics were collected from the entire area in each estuary. As far as possible surface temperature and turbidity were noted regularly. Water samples were collected one foot below the water surface and brought to the laboratory for analysis. Turbidity was determined by the Seechi's disc. and Velocity of water by the float method. Plankton samples and bottom fauna were preserved in 5 per cent formalin for examination in the laboratory at a convenient time. Plankton was collected in No. 21 bolting silk net of 2 feet length and 6 inches diameter drawn through the water for a space of three minutes. The volume of each collection was standardised to one litre and a sub sample of one cubic centimetre employed for numerical estimation of the organisms present. The total volume of plankton sediment was estimated by setting the entire collection in a conical glass Sedimenter. Water and soil analysis were done according to standard methods in vogue.

Observations.

A. *Hydrological features.*

1. *Thermal conditions.*—The estuaries surveyed are spread over a distance of 50 miles, as mentioned earlier, and yet there is only negligible difference in their air temperature. The range of both air and water temperature are similar in all the estuaries. It is to be noted that minimum air temperature is lower than minimum water temperature in all the estuaries. In the Coovum estuary, the air temperature ranges between 28 ° C to 33·5 ° C but in November 66 it was even as low as 24 °C. This was the period of heavy rainfall. The water temperature ranges between 25 °C to 33·5 °C and was found to continue to be low in the succeeding few months after November 66 although the air

temperature increases. The river experiences floods at this period and also occasional rains. No significant difference was found between the temperature of the three stations of an estuary though it is commonly known that the farther from the sea the colder it is in winter and the warmer it is in summer. Generally during the summer months of March, April, May and June water temperature was found to be slightly higher whereas in winter months water temperature was low. The difference between water and air temperature in the winter months is nearly 2 °C. In the Covelong Estuary, the air temperature ranges from 24 °C to 35 °C and water temperature from 24 °C to 32·5 °C. There is no significant difference between the stations and between the North and South ends which are at a distance of fifteen miles. Here the water temperature is always lower than the air temperature except during the month of November 1966, the period of rains. This is the reverse of conditions prevailing in the Coovum. In the Pudupattinam estuary the air temperature ranges from 23 °C to 33 °C and water temperature from 24 ° C to 32·5 ° C. There is no difference in temperature between the stations. In the summer months of April and May water temperature is usually higher than the air temperature but there was an exceptional case in the second station in November 1966, the month of rains, when water temperature was higher than air temperature. In the Palar estuary the air temperature ranges from 24 °C to 34 °C and water temperature ranges from 25 °C to 32·5 °C. During winter months water temperature is higher than air temperature only at the mouth and occasionally at the third station and in summer it is always less than air temperature.

2. *Turbidity.*—In the Coovum it is very high and ranges from 12 cms. to 39 cms. It is highest in the second station. Turbidity was high from April onwards. It was slightly less in the months of rain and floods. High turbidity was found not only when there was suspended organic debris but also when there was a development of green surface scum.

In Covelong, both at the north and the south ends, turbidity is very low but at the third station of the North end of the estuary it is always high compared to the other stations. Here it ranges between 27 cms. to 62 cms. whereas at other stations it ranges from 43 cms. to 112 cms. In December it is very high and generally decreases after that, the highest turbidity coinciding with the time of floods. At Pudupattinam, it ranges from 39 cms. to 97 cms. At Palar there is not much difference between the stations. It ranges from 21 cms. to 96 cms. but in the month of February turbidity increases very much and is only as much as 5 cms. The turbidity is very high during the periods of floods and rains, i.e. from November onwards.

3. *Velocity of water.*

Coovum.—Here it never exceeds 30 feet per minute.

Covelong.—It ranges from 40 feet to 140 feet per minute at the mouth whereas it is negligible at the farther ends.

Pudupattinam.—It ranges from 3 feet to 20 feet per minute.

Palar.—At the mouth the velocity ranges from 60 feet to 120 feet per minute.

4. *Salinity.*—Salinity of the different estuaries vary greatly as also between the stations of the same estuary, unlike the temperature. which has not exhibited significant variations. Of the four estuaries, Coovum records the lowest salinity whereas the salinity is rather high at Covelong and Palar. Whereas freshwater conditions exist for many months in the Coovum as well as during the months of heavy floods at the mouth of the Palar, the range of salinity being 0·84 °/09 to 1·12 °/00, freshwater conditions are never met with, in the other two estuaries, at Covelong and Pudupattinam.

Coovum.—Salinity ranges from 0·82 °/00 to 11·6 °/00. In October 1966 it was found to rise up to 48·5 °/·0 at the mouth, immediately after the opening of the bar. This was noticed in 1967 also. After phenominal rise in October, it suddenly dropped during the next month and this coincided with the commencement of floods and rains. Salinity continued to drop gradually upto February, after which slight rise and fall was registered in the succeeding months. Estuarine conditions do not exist beyond the third station.

Covelong.—Salinity is quite high in both the North and South ends. At the north end it ranges from 9·31 °/ to 57·5 °/·0. Differences exist between the third station and the other two stations at this end. At the first two stations it ranges from 30·28 °/00 to 54·83 °/00 and at the third station it ranges from 9·31 % to 57·1 °/00 which is a very clear contrast. In November 1966 when the other two station recorded 40·8 in the third station it was only 9·81 Whereas with the second opening of the bar in February 1966 the salinity increased upto the fifties in the first two stations but only gradually in the third station upto May, and then fell gradually in the succeeding months till the twenties were reached by October 1966. The low salinity in November 1966 at the third station is probably due to rain and floods whereas the high salinity at the other two stations is probably maintained by tidal influx. With the receding of floods, the salinity at the third station was found to gradually rise. It is not clear why there was a fall after May, even though there is no significant fall in the temperature or the registering of local rains. The possibility of rain fall in inland places and consequent drainage of fresh water into the backwater is however quite possible. At the South end salinity ranges from 5·14 ‰ to 56·75 ‰ Even though the bar was open in November 1966, the salinity was as low as 19·38 °/ₒ and dropped further in December 1966. With the closure of the bar in January 1967 it rose up till July 1967 and then recorded a gradual fall. The fall after July is again probably due to inland water drainage due to showers in the surrounding inland places.

Pudupattinam.—Here also the salinity is high. It ranges from 5·14 % to 5·16 %. With opening of the bar, the salinity was high in November 1966 after which there was a steep fall and then a gradual increase up to July. There is a second steep fall after this and a second gradual increase. The first steep fall is due to floods but the reason for the fall in August is not clear and is probably due to land drainage.

Palar.—Salinity is high in the Palar. It ranges from 14·98 ‰ to 59·7 ‰ but for the fresh water conditions which exist in November and December, when a low salinity of 0·84 ‰ was recorded. There is no difference in salinity between the three stations studied. Upto December 1966, the salinity was near to fresh water conditions even though the bar was open. Heavy floods were noticed during this period. After December 1966 salinity gradually increased up to June 1967 and then gradually decreased.

5. *Dissolved Oxygen.*—But for Coovum at all the other places dissolved oxygen contents were quite normal throughout the period of survey. In Coovum, Oxygen deficiency is very common, especially in the second and third stations. Dissolved oxygen was high only during the months of January and February and that too not in the third station. Dissolved oxygen contents range from nil to 6·58 cc/L. At Covelong dissolved oxygen contents are more at the South end than at the North end. It ranges from 1·154 to 7·07 cc/L at the North end and 2·92 to 8·53 cc/L at the South end. At the North end, Oxygen contents are more at the third station than at the other stations. Oxygen contents fluctuate from month to month at both ends. At Pudupattinam, Oxygen contents range from 1·12 to 7·5 cc/L. There is no difference between the stations. Oxygen contents are more during November and December. Low oxygen contents are recorded in the months of June, July, August and September the lowest being in the month of July. In the Palar, the dissolved oxygen content is fairly good at all three stations. It ranges from 2·53 to 7·16 cc/L.

6. *PH.*—In all the estuaries, the condition of the water was always alkaline. The Coovum estuary is highly alkaline throughout the year at all stations. PH ranges from 8·0 to 8·4. Covelong waters are also highly alkaline and pH ranges from 8·0 to 8·4. In Pudupattinam it ranges from 8·0 to 8·3 and in the Palar from 8·0 to 8·6.

7. *Carbondioxide system.*

Coovum.—Free carbondioxide was present during most of the months of the year and ranged from 2ppm. to 5 ppm. As such carbonate was rare. Whenever carbonate is present it ranged from 3 to 4 ppm. Bicarbonate was present throughout the 12 months and ranged from 8 to 37 ppm. It was always higher at the third station. Bicarbonate gradually increases up to June and decreases in the succeeding months.

Covelong.—Carbondioxide was present during most of the months at the North end. At the South end however carbondioxide and carbonate were present and were equally distributed among the different months of the year. Carbondioxide ranged from 1·65 to 4 ppm. at both ends whereas carbonates ranged from 3 to 4 ppm. Bicarbonate was present throughout the 12 months, being higher at the South end. It ranged from 4 to 20 ppm. at the North end and 7 to 28 ppm. at the South end.

Pudupattinam.—Carbondioxide was present for over 8 months at both stations and ranged from 1·6 to 5 ppm. During the months of September and October carbondioxide was present at one station and absent at the other. Carbonates ranged from 2 to 5 ppm. Bicarbonates ranged from 7 to 26 ppm. and there was not much difference between the stations.

Palar.—Carbondioxide was present throughout all the months but for the third station in the month of July. The difference between the stations was little. It ranged from 1·65 to 5 ppm

In the case of bicarbonates it ranged from 6 to 15 ppm. and the pattern was almost the same at all the places.

8. *Phosphates.*

It is present in good quantities at all the places throughout the twelve months. It ranges from 0·33 to 0·89 ppm. in the Coovum, 0·37 to 0·59 ppm. at Covelong, 0·35 to 0·49 ppm. at Pudupattinam and 0·16 to 0·51 ppm. at Palar.

B. *Plankton.*

Coovum.—Plankton is generally very poor and is dominated by *Cynophyceae*, and *Bacillariaceae*. The plankton sediment ranges from 0·05 to 2·0 cc. but much of the plankton sediment is invariably formed of organic debris. The major phytoplankters recorded were *Anabaena, Spirulina, Oscillatoria, Microcystis, Nitzchia, Navicula* and *Chlorella* and the predominant Zoo plankters were Copepods, Nauplius larvae and *Brachionus*. Other Phytoplankters recorded were *Merismopedia. Distephanus, Pleurosigma, Coscinosira, Fragillaria, Chaetoceras, Synedra, Coscinodiscus, Thallasiothrix, Rhizosolenia* and *Scenedesmus*. The other Zooplankters were Nematodes, Formaminifers, *Euglena*, Trochophore larvae. *Cypris*, Daphnids and Oligochaetes. Blooms of *Microcystis, Spirulina* and *Oscillatoria* were common, forming green surface scum. Daphnids occured in abundance during the month of August in the third station, when the salinity was 3·7 °/00 Zooplankton was abundant only in the months of May and June and *Brachionus* occured in large numbers, at this time.

Covelong.—From the data analysed, there is clear evidence that plankton is richer at the north end than at the south end. Though zooplankton is poor, compared to the available phytoplankton, it is far better represented at both the places than in the Coovum Estuary. The presence of *Noctiluca, Ceratium* and *Peridinum* is interesting. There is no difference in the occurrence of plankton species, between the north and south ends. In November, the plankton is very poor but improves in the succeeding months and is again poor in September and October. *Cyanophyceae*, and *Chlorophyceae* were negligible unlike as in Coovum. The major planktonic organisms are *Anabaena* among the *Cynophyceae, Coscinodiscus, Chaetoceros, Bacteriastrum* and *Rhizosolenia* among the *Bacillariaceae* and *Foraminiferans*. Copepods, and Naupli among the Zooplankters. Plankton sediment ranges from ·075 to 2·0 cc. but was generally less than 0·5 cc. Organic debris is generally little when compared to that of the Coovum. The other phytoplankters recorded were *Merismopedia*, *Oscillatoria, Nostoc, Nodularia, Spirulina, Microcystis* among the *cyanophyceae, Distephanus, Nitzchia, Navicula. Thallasiothrix, Pleurosigma, Fragillaria, Coscinosira, Ditylum, Thallasiosira* among the *Bacillariaceae*. *Tetraedon trigonum, Sphaerocystis, Closterium* and *Oedogonium* among the *chlorophycae*, and *Ceratium, Trochophore* larvae, *Copepods*, Nauplius larvae, *Brachionus. Chaetognatha, Peridinium, Nematdoes, Cypris*, Larval bivalve and larval gastropod among the Zooplankters. There was an inexplicably heavy growth of *Microcystis* in the month of June only.

Pudupattinam.—Plankton sediment ranged from 0·05 to 3 cc. and it was more at the mouth. Unlike the other estuaries, zooplankton was well represented although phytoplankton was predominant. The phytoplankters were represented by *Anabaena, Spirulina, Merismopodia, Coscinodiscus, Nitzchia. Chaetoceras, Navicula, Fragillaria, Synedra* and *Bacteriastrum* and the Zooplankters by *Foraminifera, Euglena. Trochephore larvae, Copepods, Naupllus larvae, Brachionus* and *Ceratium*. The occurrence of Foraminiferans in good numbers is a significient feature.

Palar.—The sediment ranged from 0·1 cc. to 2·0 cc. Plankton was better represented than in the Covelong Estuary and as in other estuaries was dominated by phytoplankton. The occurrence of zooplankton was less than in the Covelong estuary. The plankton sediment was invariably full of organic debris. The major phytoplanktonic organisms of this estuary are *Anabaena, Coscinodiscus. Thalasiothrix, Coscinosira* and *Rhizosolenium*. Other phytoplanktonic organisms present were *Nostoc, Nodularia, Spirulina, Merismopedia, Oscillatoria, Microcystis, Coelosphaerium, Distephanus, Nitzchia, Chaetoceras, Navicula, Pleurosigma, Fragillaria, Synedra, Bacteriastrum, Pediastrum, Thallasiosira, Biddulphia, Asterionella, Gyrosigma, Staurastrum, Tetracdon trigonum, Sphaerocystis*, and *Chlorella*. Zoo organisms consisted of *Ceratium*, Nematodes, Copepods, Nauplius larvae, *Brachionus*, *Cypris, Chaetognatha* and Oligochaetes.

C. *Fishery :*

Coovum.—The fishery is very poor. The different species of fish found in the commercial catches are Glossogobius, Catfish, Mullet, Hemirhampus, Therapon species, Gerres species, Sillago sihama, prawns and Barbus sp. The size ranges of these fish varied from 6·4 to 19 cm., 5·6 to 16·2 cm., 7·9 to 28·4 cm., 6·8 to 13·8 cm., 4·1 to 13·7 cm., 5·6 to 17·1 cm., 7·1 to 23·5 cm.. 6·7 cm. to 12·8 cm. and 5·0 to 9 cm. respectively. Catfish formed the majority of the catches followed by Mullet, Prawns and Barbus sps. The presence of *Barbus* sps. in good numbers is a significant feature indicating the fresh water conditions in the estuary. Fishing was found to be rare beyond the second station.

The fishing gear used consists of castnets, rod and line, katcha valai and pachuvalai. No crafts are used normally, but when the bar closes, catamarans are sometimes used for the operation of cast nets. Only fishermen who fish in the sea from the adjoining fishing hamlets fish in this estuary also.

Covelong.—A very good fishery is found at the North end of this estuary. The fish caught are Catfish, *Gerres* sp., *Therapon* sp., *Sillago sihama*, *Caranx* sp. Prawns, *Hemirhampus*, Mullets, Crabs, *Equula* sp. *Etroplus* sp. and *Gibus* sp. The size of these fish range from 7·3 to 18·2 cm., 5·5 to 14·2 cm., 5·8 to 16·2 cm., 4·2 to 16·5 cm., 5·5 to 27·4 cm., 7·5 to 21·8 cm., 6·0 to 20·3 cm., 11·6 to 21·1 cm., 6·8 to 34·3 cm., 8·9 to 16·3 cm., 6·3 to 10·5 cm., 6·5 to 15·8 cm. and 7·3 to 18·2 cm. respectively. Prawns form over 50 per cent of the catches. Next come Mullets, Crabs, Catfishes, *Sillago sihama* and *Hemirhampus* sp. respectively. The different species of prawns available are *Penaeus indicus Penaeus carinatus, Metapenaeus monoceros* and *Metapenaeus dobsoni*. *Penaeus carinatus* of size 260 mm. and weighing nearly 50 gms. are commonly caught in the estuary at this north end. In the velons screen dragnet collections, plenty of mullet fry were caught throughout, indicating the possibilities of a good fishery. *Lutianus* sp. and *Cynoglossus* sp. fingerlings were also collected indicating that they are also available in the estuary.

The gear used consisted of rod and line, cast net, dragnet and kondavalai. Catamarans are used for fishing. The Fishermen engaged in the estuary are from the surrounding hamlets Muthukadu, Karikattukuppam, Jambuvadai, Kovalam, Pudur, Korappathur and Kunnakadu. All these fishermen are sea going.

The fishery at the South end is only half of the fishery at the north end, although, the same varieties of fish are caught. During March and April 1967, *Tilapia* of sizes 10 to 18 cm. were available. The predominant species of fish occuring are Mullet, Prawns. Catfish, *Sillago sihama, Gerres* sp., *Etroplus suratensis* and *Lates calcarifer*.

The same type of craft and gear employed at the North end are used in the South end also.

Pudupattinam.—The fishery here is generally poor. The major fishery consists of Mullet, Prawn, Catfish, *Platycephalus* sp., *Therapon* sp., *Gerres* sp., *Equula* sp. and *Etroplus suratensis*. Occasionally *Gobius* sp.. *Hemirhampus* sp. and crabs are caught. The size range of these species available are 5·0 to 31·0 cm., 6·0 to 15·6 cm., 5·0 to 16·3 cm., 6·0 to 17·4 cm., 7·3 to 27·3 cm., 4·8 to 14·3 cm., 5 to 12·9 cm., 9·5 to 11·4 cm., 17·8 to 26·0 cm. and 7·0 to 11·0 cm. respectively.

Palar.—The fishery here is highest among all the estuaries. The fish commonly available are Catfish. *Therapon* sp. *Sillogo sihama, Gerres* sp., *Equula* sp., Mullets and Prawns. Occasionally *Hemirhampus* sp., *Etroplus suratensis, Elops indicus, Lates calcarifer, Platycephalus* sp., *Plynemus* sp. and Rays are caught. The predominent fish species in the ratio of their abundance are Prawns and Mullets forming nearly half of the catches and are followed by *Gerres* sp.. Catfish, *Sillago sihama* and *Lates calcarifer*.

The gear used are rod and line, castnet, dragnet and Kondavalai. Catamaran is the only craft used.

Summary.—This survey was begun in November 1966. The data collected for twelve months have been given in this paper. The Coovum, Pudupattinam and Palar estuaries have probably been formed as Drowned River Valleys whereas the Covelong has probably come into existence by the formation of a barrier beach. Although these four estuaries are spread over a distance of 50 miles, Temperature does not vary much, in all these estuaries. The minimum surface water temperature is found to be higher than the minimum air temperature generally but in the Coovum and Pudupattinam estuaries water temperature is higher than air temperature in summer and lower than air temperature in winter. At Covelong and in the Palar water temperature is always lower than air temperature but for occasional instances. Coovum records the highest turbidity throughout the twelve months whereas at the other estuaries the water is fairly clear and turbidity is found to be a little high only during the periods of floods and that too at the third Station which is farthest away from the mouth. Again Coovum differs from the other estuaries with regard to Salinity. While in the Coovum, Salinity is very low for a number of months and is near to fresh water conditions even at the mouth. in all the other estuaries, the salinity goes down with the rains and floods and reaches fresh water conditions only at that period. In all these three other estuaries the minimum and maximum Salinities are met with in the station farthest away from the sea. Dissolved oxygen content, is fairly good in all the estuaries but for the Coovum where oxygen deficiency is met with during many months. Free carbondioxide is present at the Palar throughout the 12 months whereas at other places Carbonate is present instead of Carbondioxide for a few months. Bicarbonate is higher in Coovum ranging from 8 to 37 ppm. whereas at the Palar it is low ranging from 6 to 15 ppm. Nutrients like phosphate and silicate are present in adequate quantities in all the estuaries. Plankton is generally poor in all the estuaries. Covelong and Palar have more plankton production comparatively, while it is significantly poor in the Coovum. However, phytoplankton was found to predominate in all the estuaries. *Cyanophyceae* predominated in the Coovum while *Chlorophyceae* predominated in the other estuaries. Diatoms were second in predominance. Green surface scum formed by phyto organisms such as *Microcystis, Oscillatoria, Spirulina* and *Chlorella* were common throughout the Coovum estuary during most of the year but were not present in the other estuaries throughout the 12 months. The fishery was heaviest in the Palar and was followed closely by that of the north end of the Covelong estuary. It was poor in Coovum. Prawn catches were heavy in the Covelong and Palar estuaries.

Discussion.

All the four estuaries have sand bars of varying widths. This is a barrier limiting the productivity of the estuaries as the fishery of the estuaries depend solely on the entry of fish from the sea into the estuary. Very little fish migrates down from the fresh water upper reaches. Entry from the sea is possible only during the short period when the bar is open. The bar is open for 5 months at the Coovum just over two months at Pudupattinam, 6 months at Covelong and 9 months at Palar. In all the estuaries, the bar opens by the action of floods and tides during the winter months. With the first opening of the bar, the water from the estuaries flood into the sea and thus fish are also emptied into the sea. After this the estuaries await an entry of new arrivals from the sea and this is possible only after the floods from the river subside and tides enter the estuary. An open bar for over 6 and 9 months respectively at Covelong and Palar is one of the reason for the heavy fishery in these estuaries.

Whereas all the other estuaries record high salinities it is not clear why the Coovum alone records low salinities. In the Coovum high salinity was recorded only at the mouth just after the opening of the bar. Probably the tides are not high or sufficiently strong enough for the saline water to force its way far up the estuary. On the contrary it is quite possible that the flow of sewage of the Madras City is sufficiently heavy to reduce the salinity. This low salinity may be one of the reason for the poor fishery in the Coovum. The poor fishery in Pudupattinam however is not due to this but is due to the fact that the bar is open for just over two months. With all this, the fishery is far better than that of the Coovum. In all the other estuaries, salinity does not go down below 9·0 % but for one or two months of heavy floods in the Palar. This was so in the year 1966 as the rainy season happened to be a season of heavy floods but during seasons of normal rains, fresh water conditions may not be met with at all even for those one or two months, in these estuaries.

The occurrence of oxygen deficiency during many months and the presence of green nauseating scum on the surface of water during most of the months in the Coovum is an indication of the extent of pollution of the estuary. The pollution is mainly the result of the entry of sewage of the Madras City rather than the pollutants from chemical factories. The pollution of the Coovum estuary by the untreated sewage of Madras has been going on for over many years. This is reflected in the high bicarbonate contents and very high turbidity in the estuary. Whereas at present, the turbidity ranges from 12 to 39 cm. and is usually below 25 cm., in 1958-59 J. G. Abraham recorded only 34 to 45 cm. of turbidity. Except in the second station, turbidity was found to range from 18·2 to 37·5 cm. Thus low salinity, oxygen deficiency and pollution by sewage in combination have reduced the fishery of this estuary to the lowest level. It is interesting to note that there are reports by fishermen that in the year 1950 and 1951 there was a good fishery of prawn in this estuary. The formation of green scum by *Oscillatoria, Spirulina* and *Mycrocystis* can be considered as indications of the extent of pollution of an estuary, as the same condition though to a lesser degree is present in the adjacent estuary in the Madras City, the Adyar estuary but is completely absent in the other three estuaries. The presence of a good fishery in Adyar estuary and just the opposite in the Coovum goes to further prove that sewage pollution affects the fishery to a very grea extent. Further the Adyar estuary records high salinities, unlike Coovum. This survey proves the necessity to take precautionary steps at the very start to prevent pollution of the other estuaries which are now in good condition. Estuaries are the best sources for the delicious prawn dishes of our tables as well as the crab, the other tasty crustacean. Pulicat lake in Chingleput district substantiates the above statement. The atomic power plant coming up at Madras is a threat to the survival of the fisheries of the Pudupattinam estuary. Immediate action is called for to see that effluents from this reactor are not turned out into the estuary or into the sea near the mouth of the estuary.

Suggestions.

This survey has shown that the North end of the Covelong estuary and the Palar estuary yield a good fishery. Further research programmes concentrated at these two places will yield valuable data. Based on the information gathered so far both places are very suitable for the establishment of fish farms. The Covelong North end is first best in that a suitable site is also available for construction of a farm, and floods are rare as there is no river entering the backwaters. Just a little further from the north end towards the village of Covelong, there is the creek, similar to the creek in Adyar estuary where the estuarine farm has been constructed. This creek also is a collection ground for fry and fingerlings as in the case of the Adyar Creek. In fact, the Adyar estuarine farm depends on the creek for its source of fish seed. Preliminary investigations reveal an abundance of prawn post larvae and Mullet fry in the Covelong backwater which can be collected and farmed on a commercial scale. To add to this, extensive beds of edible oyster, Ostrea madrasensis are also available in the Covelong creek making Oyster culture and farming a possibility. Besides this, Sillage sihama a much sought for fish by fish eaters, is also available in good numbers in this estuary. The occurrence of Penaeus carinatus above 200 mm. in size and the regular fishery that exists is an interesting feature. This is very significant as such large sized Penaeus carinatus were not available in any of the other estuaries surveyed. They usually migrate back into the sea at still earlier stages. Probably, unknown conditions exist which prevent these prawns from migrating back to the sea. This has to be investigated further.

Acknowledgment.

We appreciate the help rendered by **Thiru K. P. Srinivasan, Fishery Overseer in collecting** samples for analysis and **gathering other relevant data.**

References :—

1 Abraham, J. G. .. .. (1959) A Survey of the Hydrobiology and Fisheries of the Coovum river. Madras Journal of Fisheries 1 pp 50–69.

2 Alexander W. B. Southgate, B.A., and Bassindale, R. (1932) The Salinity of the water retained in the Muddy Foreshore of an Estuary. J.M.B.A. of U.K. Vol. 18 pp 299–306.

3 Bassindale, R. .. .. (1938) Intertidal fauna of Mersey Estuary. J.M.B.A. of U.K. Vol. 23 pp 83–98.

4 Cooper L.H.N. and Milne, A. .. .. .. (1938) Ecology of Tamar Estuary 2. Under-water illumination. J.M.B.A. of U.K. Vol. 22 pp 509–528.

5 George, K. Reid .. .. Ecology of Inland waters and Estuaries.

6 Hartley P.H.T. and Spooner, G.M. .. .. (1938) Ecology of Tamar Estuary 1. J.M.B A. of U.K. Vol. 27 pp 213–226.

7 Ketchum, B.H. .. .. (1953) Circulation in Estuaries. Woods Pole Oceanographic Institute Contribu, tion No. 642 pp 65–75.

8 Milne, A. .. .. (1938) The Ecology of Tamar Estuary 3. Salinity and Temperature conditions in the lower estuary. J.M.B.A. of U.K. Vol. 22 pp 529–542.

9 Percival, E. .. .. (1929) A report on the Fauna of the Estuaries of the river Tamar and the river Lynker. J.M.B.A. of U.K. Vol. 16 pp 81493.

10 Spooner G. M. and Moore, H.B. .. .. (1940) The Ecology of the Tamar Estuary. J.M.B.A. of U.K. Vol. 24 pp 283–330.

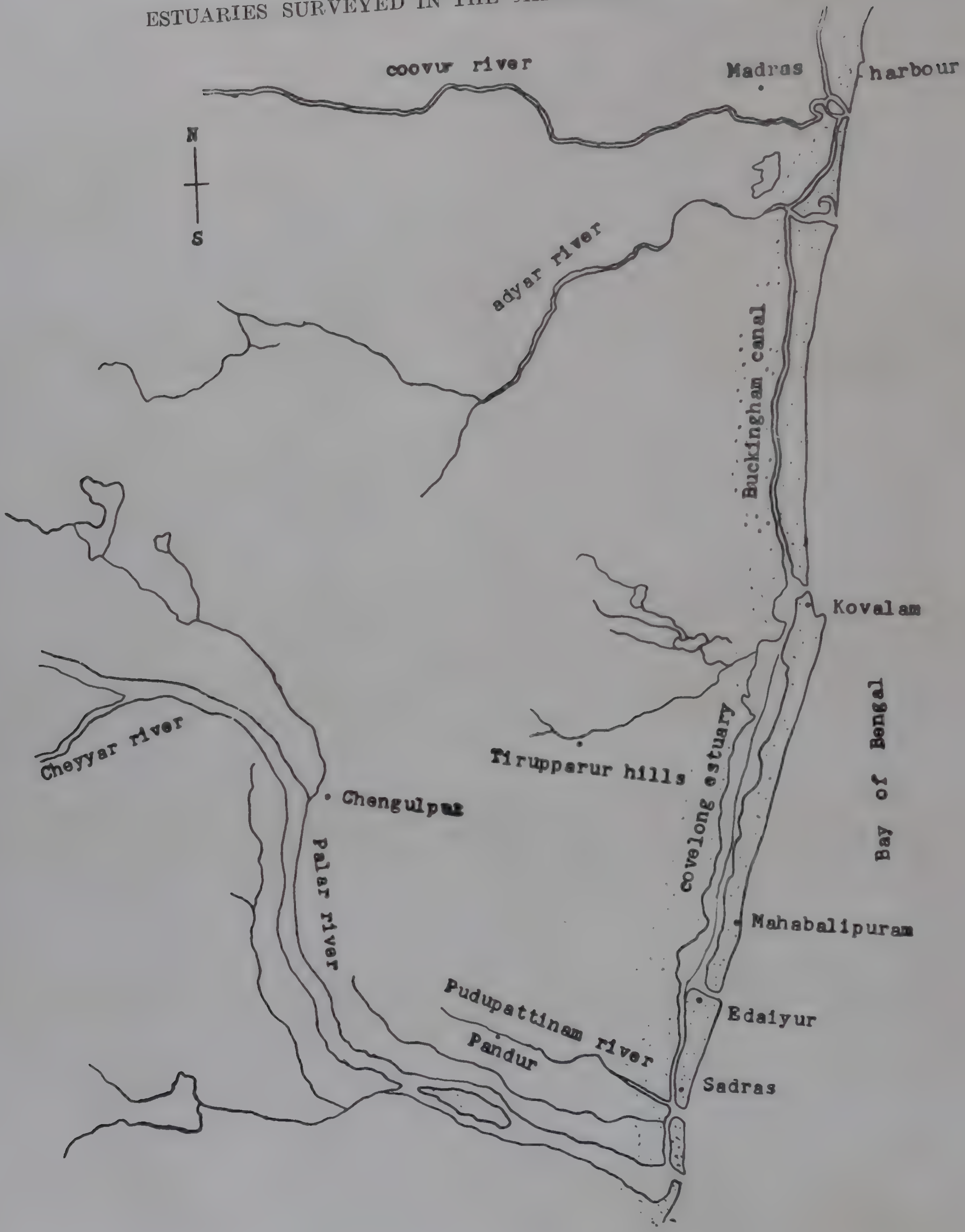
Hydrographical range for the year 1966–67.

	Coovum estuary.			Pudupattinam estuary.		Covelong estuary.					Palar estuary.		
	River Mouth.	*Place 2*	*Place 3*	*River Mouth.*	*Place 2*	*North end Mouth 1.*	*Place 2*	*Salt Pan East 3.*	*South end Mouth 4.*	*Place 5*	*River Mouth.*	*Place 2*	*Place 3*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Salinity o/00	1·75 to 48·5	1·92 to 8·55	0·82 to 7·56	5·34 to 51·6	5·12 to 47·5	15·85 to 50·8	15·85 to 50·8	9·31 to 56·89	5·14 to 56·75	5·24 to 53·45	0·946 to 57·9	1·23 to 52·18	1·137 to 52·3
Oxygen Content cc/L ..	Nil to 6·58	Nil to 6·15	Nil to 2·94	2·56 to 7·0	1·32 to 7·5	2·52 to 7·3	1·154 to 7·03	1·57 to 6·52	2·198 to 7·35	2·98 to 7·0	2·53 to 4·82	2·53 to 5·05	2·85 to 7·06
Ph.	8·2 to 8·4	8·1 to 8·4	8·0 to 8·4	8·0 to 8·4	8·0 to 8·3	8·0 to 8·4	8·2 to 8·4	8·1 to 8·3	8·0 to 8·4	8·1 to 8·3	8·0 to 8·6	8·1 to 8·4	8·1 to 8·3
Free Carbondioxide ppm.	Nil to 4·0	Nil. to 3·0	Nil to 5·0	Nil to 5·0	Nil to 5·0	Nil to 3·0	Nil to 4·0	Nil. to 4·0	Nil to 5·0	Nil to 5·0	Nil to 3·0	Nil to 4·0	Nil to 3·0
Carbonate ppm.	Nil to 4·0	Nil to 3·0	Nil	Nil to 4·0	Nil to 4·0	Nil to 3·0	Nil to 3·0	Nil to 4·0	Nil to 6·0	Nil to 4·0	Nil to 3·0	Nil to 4·0	Nil to 4·0
Bicarbonate ppm. ..	8·0 to 24·0	9·0 to 37·0	11·0 to 29·0	4·9 to 26·0	5·0 to 20·0	4·0 to 15·0	6·0 to 20·0	4·0 to 13·0	6·0 to 25·0	7·0 to 28·0	19·0 to 25·0	18·0 to 28·0	18·0 to 26·0
Phosphate ppm. ..	0·38 to ·45	0·39 to 0·41	0·37 to 0·57	0·39 to 0·48	0·37 to 0·45	0·39 to 0·52	0·40 to 0·57	0·39 to 0·57	0·39 to 0·45	0·37 to 0·43	0·38 to 0·45	0·37 to 0·47	0·287 to 0·43
Silicate Mgm./L	14·0 to 38·0	18·0 to 25·0	18·0 to 25·0	14·0 to 30·0	18·0 to 25·0	22·0 to 25·0	20·0 to 30·0	18·0 to 28·0	18·0 to 25·0	12·0 to 28·0	19·0 to 25·0	18·0 to 22·0	15·0 to 26·0
Temperature in °c—Air.	24·0 to 33·0	29·0 to 34·0	27·0 to 33·0	24·5 to 33·0	25·5 to 32·5	25·0 to 33·0	24·0 to 33·5	26·0 to 32·0	25·0 to 33·0	24·0 to 33·0	25·0 to 33·0	25·5 to 33·5	24·0 to 33·0
,, Water ..	22·0 to 33·0	26·0 to 32·5	26·5 to 32·5	25·0 to 31·0	24·5 to 31·5	25·0 to 32·0	25·0 to 32·5	25·0 to 31·5	25·0 to 32·0	25·0 to 32·5	24·0 to 31·0	26·0 to 32·5	25·0 to 32·5
Turbidity in cms. ..	17·0 to 52·0	18·0 to 38·0	12·0 to 59·0	39·0 to 78·0	26·0 to 96·0	42·0 to 112·0	43·0 to 91·0	27·0 to 62·0	52·0 to 73·0	53·0 to 91·0	26·0 to 96·0	19·0 to 78·0	28·0 to 85·0

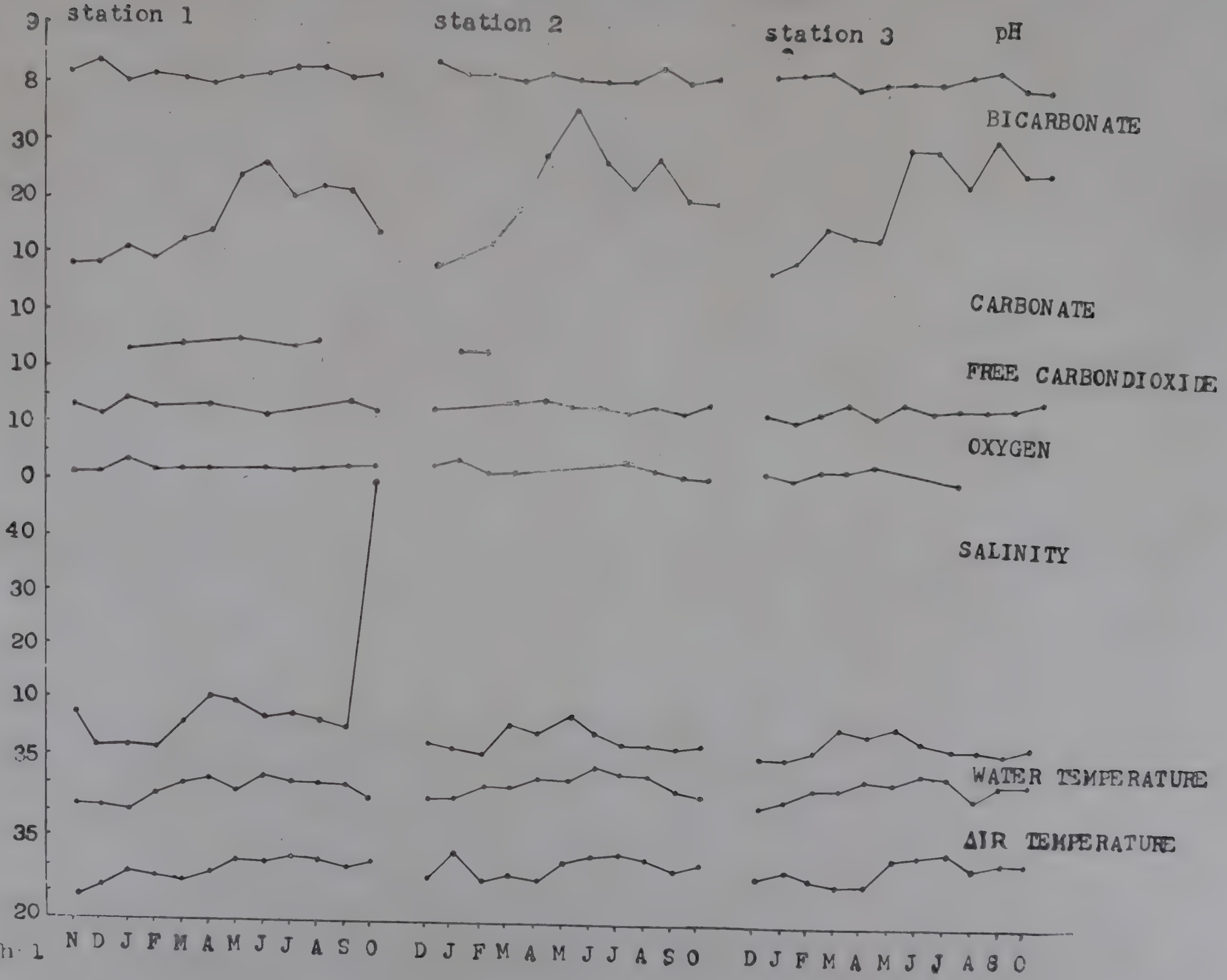
Soil Analysis range for the year 1966–67.

	Coovum estuary.			*Pudupattinam estuary.*		*Covalong estuary.*					*Palaar estuary.*		
	River Mouth.	*Place 2*	*Place 3*	*River Mouth 1*	*Place 2*	*North end Mouth.*	*Place 2*	*Salt Pan' east 3.*	*South end Mouth 4.*	*Place 5*	*River Mouth.*	*Place 2*	*Place 3*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Chloride ppm.	50 to 150	50 to 100	20 to 50	50 to 200	50 to 150	100 to 200	100 to 150	100 to 200	100 to 200	100 to 150	20 to 200	20 to 100	20 to 150
Sulphate ppm.	Traces to 20	Nil to 10	Nil to 10	Nil to 10	Nil. to 20	Nil	Nil to 20	Nil to 20	Nil to 10	Nil to 20	Nil to 20	Nil to 20	Nil to 20
Calcium ppm.	20 to 40	20 to 40	20 to 60	20 to 40	20 to 40	10 to 40	10 to 40	20 to 40	20 to 40	10 to 40	10 to 20	20 to 40	20 to 40
Ammonia ppm.	Nil to 16	1 to 2	2 to 4	1 to 2½	Nil to 16	Nil to 2½	Nil to 2½	Nil to 2½	1 to 2	1 to 2½	1 to 2	1 to 2	1 to 2½
Phosphate ppm. ..	1 to 2	1 to 2	1 to 2	1 to 2½	1 to 2½	1 to 2	1 to 2	1 to 2½	1 to 2	1 to 2½	1 to 2	1 to 2½	1 to 2
Iron ppm.	1 to 2	1 to 4	1 to 6	2	2	2	1	1 to 2	2	1 to 2	1 to 2	1 to 2	1
Nitrate ppm.	—	..	..	..	..	..	..	..	..	..	..	..	..
Magnesium ppm ..	..	..	..	..	..	..	..	..	..	..	..	..	..
Aluminium ppm. ..	...	..	..	..	..	..	..	..	..	..	..	..	..
Carbonate ppm. ..	Low to Medium.	Low to Medium.	Low to Medium.	Low to Medium.	Low to Medium.	Low to Medium.	Low to Medium.	Low to Medium.	Low to Medium.	Medium	Low to Medium.	Low to Medium.	Low to Medium.
PH. — — ..	Above 7.	Above 7.	Above 7.	Above 7 to 8.	Above 7 to 8.	Above 7·5 to 8.	7 to 8	7 to 8	8	8	7 to 7·5	8 to 8·5	7 to 8

ESTUARIES SURVEYED IN THE CHINGLEPUT DISTRICT.

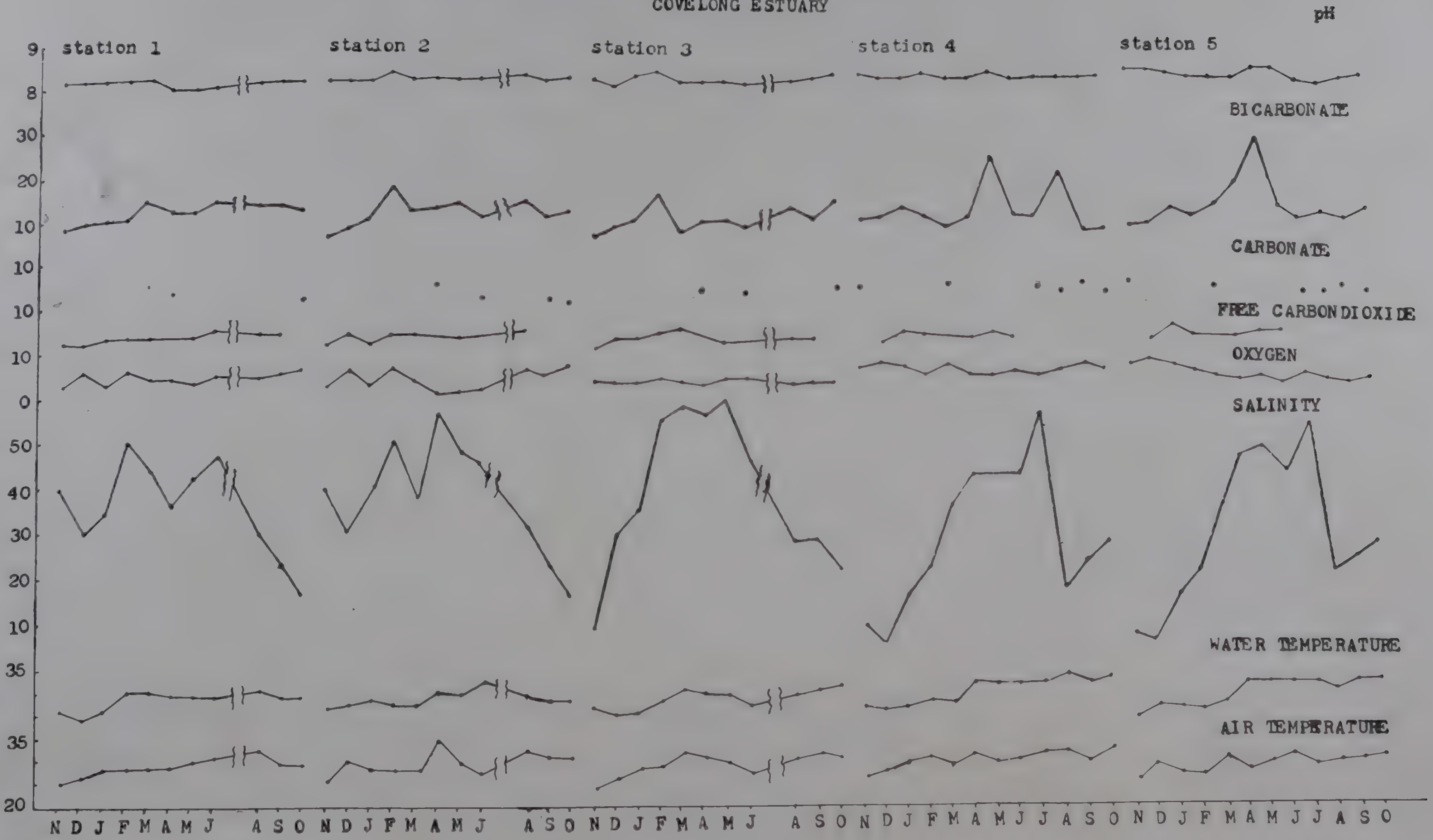

coovur river
Madras
harbour
N
S
adyar river
Buckingham canal
Kovalam
Cheyyar river
Tirupparur hills
Chengulpat
Covelong estuary
Bay of Bengal
Palar river
Mahabalipuram
Pudupattinam river
Pandur
Edaiyur
Sadras

HYDROLOGICAL FEATURES OF COOVUM ESTUARY.



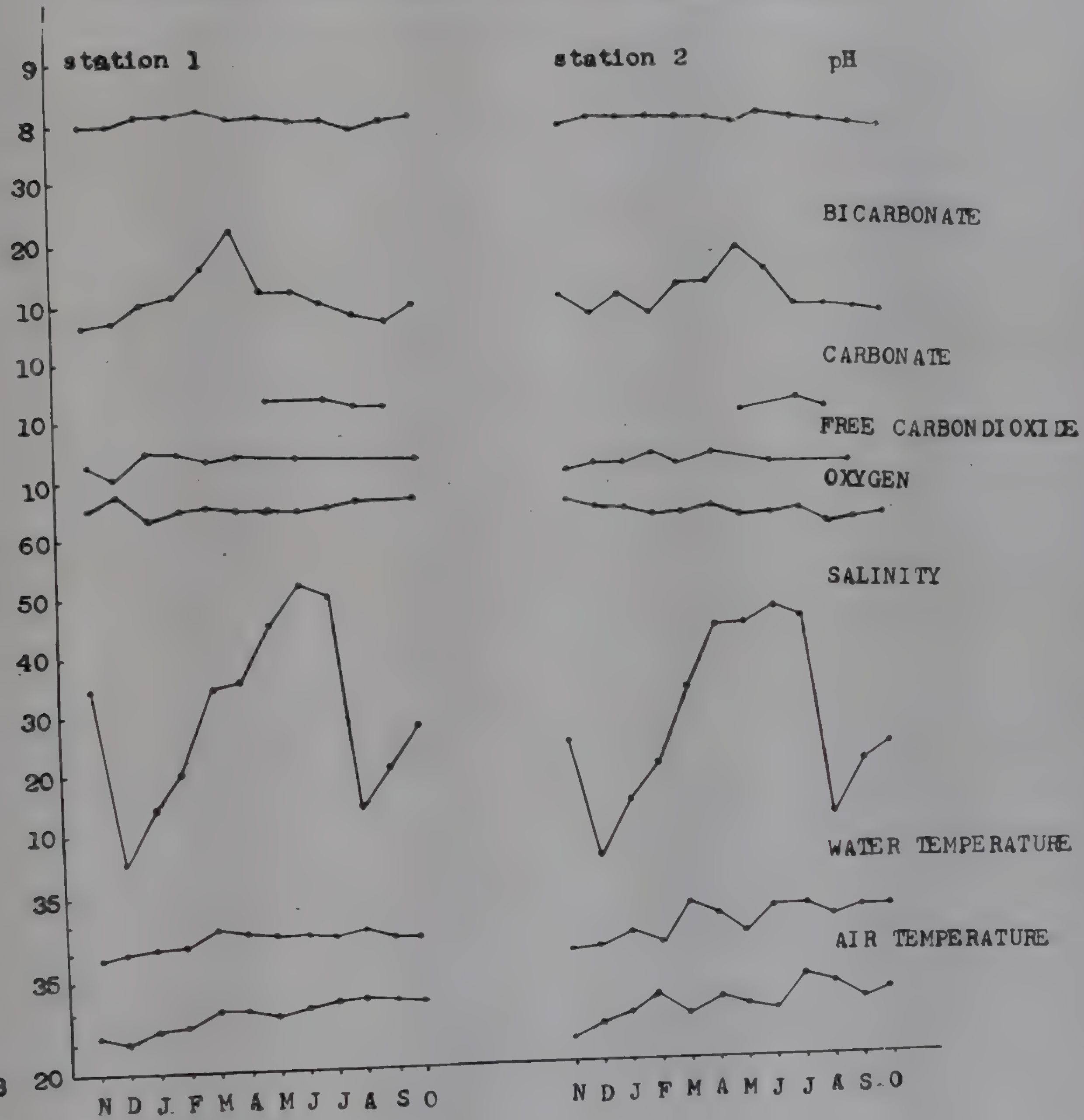
graph 1

HYDROLOGICAL FEATURES OF
COVELONG ESTUARY



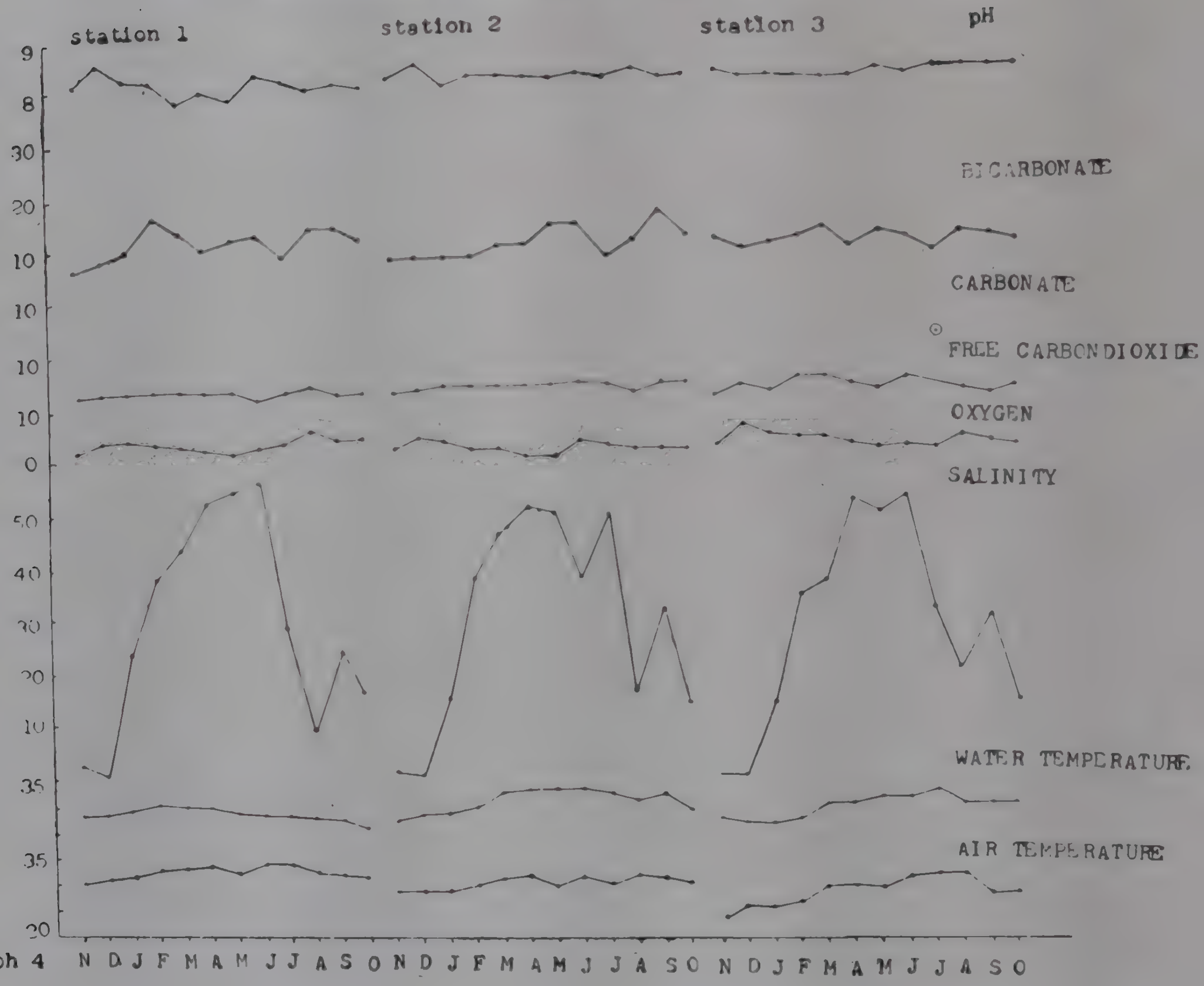
graph 2

HYDROLOGICAL FEATURES OF PUDUPATTINAM ESTUARY.



graph 3

HYDROLOGICAL FEATURES OF PALAR ESTUARY.



graph 4

HYDROBIOLOGY AND FISHERY OF THE ENNORE ESTUARY FROM JUNE 1965 TO MAY 1967.

By

Thirumathi GEMMA EVANGELINE and Thiru K. SUBBIAH, Marine Biological Station, Ennore.

Introduction.—The fishery potentiality of the Ennore Estuary in correlation with hydrological and planktological factors as observed in the period, June 1965 to May 1967 are given in this paper. Similar work has been done in the same estuary by Chacko (1954-55), Chacko and Rajagopal (1962) and by other research workers of the Marine Biological Station, Ennore (1954-55), (1955-56) and (1956-57) as is published in the Fisheries Station. Reports and Year book for those years.

A. *Topography.*—The Kortalaiyar Estuary at Ennore is three kilometres in length, one kilometre in breadth and 1 to 2·5 metres in depth and is situated exactly at the fifteenth kilometre north of Madras. The sand bar at the mouth of the river closes for nearly six months in the year and opens into the Bay of Bengal during the flood of the North-East Monsoon. This natural barrier plays an important role in the hydrobiology and fishery of the estuary. The Buckingham Canal which is in continuous connection with the sea at Pulicat lake throughout the year, cuts through, and feeds this estuary with water and larval and juvenile fishes when the river mouth is closed.

The banks of the estuary are sandy. The bottom is clayey, with an admixture of sand. The water spread area and the depth of the estuary at various points, varies with the seasons. The tidal influence, when the bar is opened, is felt far beyond the railway bridge, a distance of two kilometres with a horizontal gradient. The maximum tidal amplitude at the mouth is 80 cms.

B. *Hydrography.*—The condition of the sand bar is found to play an important role in the hydrological conditions of the estuary. It was opened from the fifth of December 1965 to the fourteenth of May 1966 and again from the fourth November 1966 to fourth June 1967. During the period of study, conditions in the estuary were found to be different from that of the sea, on the closure of the bar, even though concentration made the estuarine conditions akin to marine condition. Rainfall and flooding in winter. established conditions close to Limnological conditions. Again continuous floods. helped to force open the bar and water streamed into the sea, for a few weeks, giving rise to a Fluviatile environment.

1. *Salinity.*—The important hydrographical features which influence the physical environment of the estuary are Temperature and Salinity. The salinity of the estuary is found to vary from fresh water to almost sea water condition. The data collected during the first year have been closely compared with that of the second year (Fig. A). The salinity fluctuation when the bar was closed was found to depend upon rain, drought, temperature and evaporation while it was influenced by the tides when the bar was open. The second years data closely follows that of the first year. The highest salinity recorded for the first and second year respectively were 33·2 0/00 and 32·7 0/00 and the lowest salinity recorded was 0·07 0/00 and 0·874 00/0 in the month of November in both the years.

2. *Temperature.*—The average surface temperature varied from 24·5°C to 29·4°C. The maximum surface temperature of 34 °C reached in the two years was recorded in October 1965 and August 1966 respectively and was unusual. The minimum temperature of 24 °C and 23 °C was recorded respectively in December 1966 and January 1967.

The average atmospheric temperature indicated a similarity in its variation to the surface temperature. The atmospheric temperature ranged from a minimum of 24·5 °C in December 1966 to as much as 36 °C in May 1966. Neither the surface temperature nor the atmospheric temperature of the second year agreed with that of the first year but the average atmospheric temperature recorded in the different months closely followed the surface temperature in both the years (Fig. B). In fact, there was lower temperature fluctuation in the second year than in the former.

Tables I and II give an analysis of the weekly water samples taken at 9 a.m. near the laboratory from the surface water. Range of temperature, pH value, salinity, specific gravity and such other factors, have been recorded.

C. *Planktology.*—Regular weekly plankton hauls were made at 6 a.m. with a tow net from the middle of the estuary, for about twenty minutes and the samples were analysed both quantitatively and qualitatively. The total volume of sediment collected varied from month to month. The highest volumes of 431 cc. and 461 cc. were recorded respectively in September 1965 and August 1966 mainly due to the swarming of Mysids, *Rotifers* and Copepods. Low volumes of sediment were hauled during January and February in both years.

Nearly thirty-five planktonic organisms were recorded in the estuary during the period, of which thirteen were phytoplankters and among the remaining twenty-two Zooplankters, 9 were Crustacean forms, which constituted the bulk of the plankton. The appearance of fresh water Insect nymph was observed during the flood season.

It was interesting to note that but for *Oscillatoria*, all other phytoplanktonic forms appeared while the estuary was connected directly with the sea. The typically marine zooplankton like *Noctiluca. Foraminifers, Ceratium, Ctenophores, Lucifer, Sagitta, Oikopleura* and such others were recorded only during this period. Larval Crustaceans, Copepods, Fish eggs and larvae and the like were fairly common throughout the year. Occasionally swarming of Rotifers and Mysids were noticed and this was more common in the first year than in second year. The fluctuations in the appearance of these phyto and zooplanktonic organisms are given in Tables III and IV.

D. *Fish and fishery.*—The fishery potentiality of the estuary was such that there was a continuous and regular fishery throughout the two years. More than thirty-five species were identified. Among them sixteen species constituted 94·5 per cent of the catches (vide Tables V and VI). Many of the species were found to be seasonal migrants.

(a) Mullets.—Species of Mullets and Prawns formed the major landings. Nearly 20 per cent and 23 per cent of the total landings were mullets respectively in the first and second years. A steady peak period was noticed in the summer months of March, April, May and June. The lean months of November, December and January also registered a fall in the mullet fishery (Fig. C) in 1965-66. The Mullet fishery was found to decline slowly from October 1965 to January 1966 after which a rise was noticed in February 1966. In the second year the fall started from September 1966 itself and the rise was as early as January 1967. This was probably due to the earlier opening of the bar by a month in the second year, the bar opening on the fourth of November in 1966 and the fifth of December in 1965.

(b) Prawns.—About 18 per cent and 20 per cent respectively of the total landings were species of prawns in 1965-66 and 1966-67. Two peaks were noticed. The first peak was in May and the second was in November and December. Much depended upon the opening of the bar. Just before and after the opening there was a heavy prawn fishery. Since the bar opened in the first week of December in 1965 the prawn fishery was higher both in November and December but in the second year as the bar opened in the first week of November 1966 itself consequent to sudden and heavy rainfall a decline was noticed in the fishery in December. It was generally observed that for a fortnight after the opening of the bar, the prawn fishery showed a down ward trend. This is clearly seen in the data for January and February of both the years C (Fig. D).

(c) Crabs.—The crab fishery at Ennore is only incidental and there are no specific methods employed to catch them. An average of one thousand and fifty kgs. of crabs were caught in a month during the period of study. Though species of Neptunus were seen in the catches, Scylla species formed the major crab catch. There was a peak in the crab fishery during the summer months.

The other fishes landed throughout the year were Cat fishes, Anadontostoma species, Sillago sihama, Equula species, Gerres species, and Priacanthus species. Species of Therapon and Teuthis appeared only in the first six months of the year. Sciaena species were landed throughout except for a month or two when they appeared in very small quantities. Hemirhampus species were noticed in nine months of the year. Fishes like Lates calcarifer, Anguilla species, Engraulis species and the like did not show any regular pattern in their appearance and disappearance. Statistical details are given in Tables V and VI.

1. *General trend.*—Statistics of estuarine landings were gathered daily at the landing centres, auction centres, the cold-storage, the local market and after close contact with the fishermen who were actually engaged in the fishing of the estuary. Daily returns contained a classified list of fishes landed with their weights. The records of the past five years have proved unquestionably that the estuarine fishery is steadily on the increase

from year to year. This may be seen in the following statement:—

Weight of fish of landed from 1963 *to* 1967

1963. M. Tons.	1964.	1965.	1966.	1967.
340·75	430·02	570·40	520.0	504·01 (upto October a11967).

The monthly average landings are found to be just over forty-five metric tons in the last two years. The monthly variations, in the fishery was not high when the bar was closed. The peak season was in May and June and coincided with the heavy landings of Mullets and Prawns. During this period the water was found to be calm and clear while there was an increase in the number of fishermen fishing as fishing is more easier, effective and encouraging at such a period. It is clear from these observations that the total fish landings fluctuate correspondingly with the intensity of occurrence of individual species.

2. *Craft and tackles.*—There was no specific zonation as that of fishing and non-fishing areas. The crafts mostly used were catamarans numbering about one hundred. There were a few plank built boats also. Cast-nets were in extensive use. Drag-nets, Kondavalai, Stake-net and Angling were fairly common throughout the year and were used throughout the estuary from the sand bar to the railway bridge, mostly towards the southern banks of the estuary. Thattuvalai, a type of bag net was operated from boats mainly to catch Mullets and Anadonto stoma species. A very efficient tackle was the Kalavalai which is set directly in the fair way at the channel leading from the backwater to the sea when the bar is open. The Kattuvalai, another lengthly net, which covers the entire breadth of the estuary was also in use. Gill-nets were common. Beside this, hand-picking by groups of men and women during low tide was indulged in, as it was reasonably renumerative and compensated for the manual labour involved.

3. *Fishing Community.*—The fishermen residing at Mukathuvaram Kuppam, Kattukkuppam and Ernavur solely depend upon the estuary for their livelihood. However, fishermen of Nettukuppam and Thazhanguppam, who are sea fishermen find the estuary an alternative fishing resource when sea going is difficult during cyclonic weather. Fishermen from different parts of the Madras City such as Adyar, Rajah Annamalaipuram and Triplicane angle in the estuary or fish with cast-nets especially during night. This has made it extremely difficult to assess correctly the fishing effort, either boat var or individual var.

Conclusion.

The topography especially the depth and breadth, and the hydrographical condition of the estuary are likely to undergo a change in the next one or two years as the bar will be kept open permanently through out the year in future, as a result of the establishment of the Ennore thermal station. The body of water in the estuary will be in constant motion from the sea to the estuary and will result in a definitely higher salinity and thereby different ecological niches. There is every possibility of a restricted fish fauna with an abundance of macro and micro flora. Tidal action will bring in more organic substances and a higher level of productivity can be expected. The organic silt deposits which lead to oxygen deficiency at the bottom due to bacterial action, will be dredged periodically by the Thermal Station to maintain a required depth and resultant changes in hydrographical conditions cannot be expected. It is very doubtful whether the biota and the varied fishing seasons will continue as they are at present. However there appears to be a bright future for the development of the oyster fishery which now exists only when the estuary is directly in connection with the sea.

References.

1. Chacko, P. I. 1956.	Hydrobiology and fisheries of the Cortalliar estuary, Ennore near Madras in 1954–1955. Proc: 43rd Indian Science Congress 3, 308, 1956 (Abstract).
2. Chacko, P. I. and Rajagopal (1962).	Hydrobiology and fisheries of Ennore river near Madras. Madras Jurnal fisheries Vol. I p· 102.
3· Fisheries Station ..	Report and year books April 1954–March 1955. 1955–1956, 1956–1957 and 1957–1958.
4. George, M. J. and Krishnakartha, K.N. (1958).	Surface Salinity of Cochin backwater with reference to tide. Journal Marine Biological Association—India Vol. V, No. 2
5. George M. J. (1951) ..	Observations on the plankton of the Cochin backwater Indian Journal Fisheries Vol. V, No. 2, p. 375.

TABLE I.

Hydrology of Ennore Estuary during 1965–1966.

	June 1965.		*July* 1965.		*August* 1965.		*September* 1965.		*October* 1965.		*November* 1965	
	Max.	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Air Temperature °C. .	34	30	34	29·5	32·5	27·5	34	28·5	34	27	31·5	27
Surface Temperature °C	33	28·5	33·5	27	31·5	26·5	27·5	27·5	34	27	31	26·5
pH Value	8·4	8·0	8·2	8·0	. .	. .	8·6	8·0	8·8	8·2	9·2	8·0
Sp. Gr.	1·022	1·018	1.024	1·021	1.026	1·000	1·010	1·004	1·010	1·006	1·007	1.00
Salinity %o	30·4	26·2	29·9	28·5	13·90	22·70	17·6	9·8	21·41	7·9	16·8	0·7
R. Humidity %	96	74	100	64	100	73	100	53	96	79	100	79
Total Rain fall m.m.	450	. .	36	. .	3,895	. .	205	. .	114	. .	893	. .

	December 1965.		*January* 1966.		*February* 1966.		*March* 1966.		*April* 1966.		*May* 1966.	
	Max.	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
Air Temperature °C. .	30·5	26	30	24·5	31	26·5	32	29	33·5	30	36	30·5
Surface Temperature °C	30.5	25	30	25·5	31·5	35·5	31·5	27·5	32·5	29	34	5·30
pH. Value	8·0	8·0	8·4	8·0	8·4	8·0	8·2	8·0	8·2	8,0	8·4	8·2
Sp. Gr.	1·021	1000	1·022	1010	1·024	1020	1·026	1027	1·023	1026	1·026	101·9
Salinity %o	32·3	0·8	29·9	20·9	27·59	28·09	29·7	. .	27	32·2	32·5	23·2
R. Humidity %	96	65	96	78	91	82	91	79	92	79	92	55
Total Rain fall m.m.	172	. .	47	. .	. .	. .	. .	. .	. .	. .	50	. .

TABLE II.

Hydrology of Ennore Estuary during 1966–67.

	June 1966.		*July* 1966.		*August* 1966.		*September* 1966.		*October* 1966.		*November* 1966..	
	Max.	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Air Temperature °C.. ..	34	28	32	28	33	27	32	28	31	27	27·7	24·5
Surface Temperature °C. ..	33	27·5	32·5	27	34	25	32·5	24	32·4	26	30	29·5
pH. valuo	8·5	8·2	8·5	8·0	8·4	8·0	8·8	8·2	8·6	8·0	8·4	8·0
Sp. gr.	1·025	1·020	1·023	1·016	1·026	1·004	1·010	1·002	1·008	1·000	1·023	1·000
Salinity %o	32·7	30·5	27·18	36·77	31·70	27.30	22·09	26·31	12·93	1·94	23·68	0·864
R. Humidity %	96	61	92	72	91	67	100	75	100	78	100	83
Total Rain fall m.m. ..	78·3	137·5			439·9		197·6		428·6		71·8	

	December 1966.		*January* 1967.		*February* 1967.		*March* 1967.		*April* 1967.		*May* 1967.	
	Max.	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
Air Temperature °C	28·5	25·5	30·5	26·5	31·5	28·5	33·0	30·5	33·5	29·5	34·0	22·0
Surface Temperature °C. ..	26·1	24·0	30·0	23·0	32·5	25.0	31·0	26·5	31·5	28·0	32·5	27·5
pH. value	8·3	8·0	8·6	8·4	8·6	8·4	8·5	8·2	8·6	8·2	8·6	8·2
Sp. gr.	1·007	1·000	1·024	1·01	1·026	1·010	1·025	1·021	1·026	1·002	1.026	1·025
Salinity %o	10·41	1·551	22·87	2·26	27·59	17·09	27·39	25·0	29·24	24·71	28·32	28·59
R. Humidity %	96	67	100	82	98	78	93	77	94	76·0	96	67
Total Rain fall m.m. ..	71·8			13·2				29·6			48·6	

TABLE III.

Results of plankton analysis during 1965–66.

Serial number and name of the organism. (1)	*June.* (2)	*July.* (3)	*August.* (4)	*September.* (5)	*October.* (6)	*November.* (7)	*December.* (8)	*January.* (9)	*Februcry.* (10)	*March.* (11)	*April.* (12)	*May.* (13)
1 Coscinodiscus	..	..	..	..	..	..	15	15	12	11	21	..
2 Chaetoceras	..	..	..	..	..	..	56	9	5	18	..	..
3 Rhizosolenia	..	..	..	..	..	..	11	10	14	3	14	..
4 Pleurosigma	..	..	..	..	..	..	..	6	11	..	..	..
5 Melosira	..	..	..	..	..	..	3	..	..	12	..	..
6 Acanthometron	..	..	..	..	..	..	3	5	9	..	..	..
7 Asterionella	..	..	..	..	..	..	5	10	15	12	..	..
8 Scleretonema	..	..	..	..	..	..	..	..	9	13	14	.
9 Ditylium	..	..	..	..	..	..	12	6	..	..	..	..
10 Halosphaera	..	..	..	..	..	..	4	17	..	..	..	..
11 Oscillatoria	22	35	32	..	3	..	25	..	3	5	..	..
12 Biddulphia	..	..	..	..	..	..	..	..	..	..	..	..
13 Foraminifers	..	..	..	..	..	..	..	3	6	8	7	..
14 Ceratium	..	..	..	..	..	..	17	3	..	..	..	..
15 Noctiluca	..	..	..	..	..	..	12	3	..	..	..	..
16 Medusae	4	3	3	2	3	..	3	..	..	..	..	..
17 Ctenophores	..	..	..	..	..	..	..	..	1	..	4	..
18 Rotifers	16	120	50	120	85	120	12	1	..	29	2	..
19 Larval annelid	3	3	5	..	2	..	12	5	2	5	3	..
20 Naupleii	13	11	19	17	8	15	7	20	4	15	18	10
21 Zoea	5	4	..	..	..	..	..	2	9	12	19	7
22 Megalopa	2	..	..	..	..	..	..	..	..	4	..	..
23 Mysids	26	28	40	81	66	41	24	5	3	..	9	10
24 Cypris larvae	..	..	..	..	..	..	..	..	..	..	..	..
25 Copepods	34	32	33	40	13	20	18	19	17	19	20	21
26 Lucifer	..	..	..	..	..	..	..	..	..	..	8	..
27 Evadne	..	..	..	..	..	..	..	..	..	..	5	..
28 Amphipod	..	..	25	30	19	..	..	..	..	..	..	..
29 Insect Nymph	..	..	..	..	..	..	3	..	..	..	..	..
30 Larval bivalve	5	4	3	7	15	..	6	13	5	9	..	..
31 Larval gastropod	6	3	8	..	..	..	3	7	6	2	3	..
32 Sagitta	..	..	..	..	..	..	2	..	..	..	..	..
33 Oikopleura	..	..	..	..	..	..	6	..	2	..	3	..
34 Fish eggs	11	4	3	10	8	..	3	12	10	6	14	4
35 Fish fry	4	2	3	3	2	6	6	1	2	3	3	9

Numbers shown in 1 cc of sediment.

TABLE IV.

Results of plankton analysis during 1966–67.

Serial number and name of the organism. (1)	*June.* (2)	*July.* (3)	*August.* (4)	*September.* (5)	*October.* (6)	*November.* (7)	*December.* (8)	*January.* (9)	*February.* (10)	*March.* (11)	*April.* (12)	*May.* (13)
1 Coscinodiscus	..	..	..	..	..	..	12	14	15	16	17	20
2 Chaetoceras	..	..	..	..	..	..	14	..	..	15	25	..
3 Rhizosolenia	..	..	..	..	..	..	..	..	15	12	24	18
4 Pleurosigma	..	..	..	..	..	..	27	12	18	15	..	14
5 Melosira	..	..	..	..	..	..	..	..	..	..	45	26
6 Acanthometron	..	..	..	..	..	..	..	..	..	..	..	..
7 Asterionella	..	..	..	..	..	..	12	..	18	..	..	18
8 Scleretonema	..	..	..	..	..	..	..	13	6	..	..	..
9 Dictylum	..	..	..	..	..	..	..	..	..	..	..	..
10 Halosphaera	..	..	..	..	..	..	..	..	..	..	..	..
11 Oscillatoria	..	..	..	..	..	..	..	..	..	..	..	..
12 Biddulphia	..	..	..	..	..	..	..	6	..	..	..	12
13 Foraminifers	..	..	..	..	..	..	4	3	11	4	2	..
14 Ceratium	..	..	..	..	..	..	..	..	..	..	..	..
15 Noctiluca	..	..	..	..	..	..	..	..	..	..	..	..
16 Medusae	2	3	3	..	..	..	..	7	5	2	6	..
17 Ctenophores	..	..	..	..	..	..	..	..	..	..	..	..
18 Rotifers	..	13	..	..	22	..	..	23	..	6	15	11
19 Larvalannelid	..	5	..	..	..	..	3	3	[illegible]	6	5	6
20 Naupili	14	15	12	5	11	..	5	10	11	23	20	25
21 Zóea	5	6	..	..	3	..	..	..	3	10	9	11
22 Megalopa	..	..	..	..	..	..	..	..	2	6	..	..
23 Mysids	6	6	53	25	17	12	4	6	2	6	6	5
24 Cypris larvae	..	..	..	..	..	2	..	5	[illegible]	21	5	9
25 Copepods	14	31	47	17	19	15	12	13	[illegible]	24	18	22
26 Lucifer	..	..	..	..	..	..	4	14	6	..	7	19
27 Evadne	..	27	..	..	..	..	..	..	..	18	19	8
28 Amphipod	..	..	..	25	5	5	..	..	23	..	..	..
29 Insect Nymph	..	..	..	..	..	..	1	..	..	..	..	..
30 Larval bivalve	..	5	..	..	..	5	5	15	7	6	14	9
31 Larval gastropod	..	..	..	..	..	..	..	..	3	8	4	18
32 Sagitta	..	..	..	..	..	..	..	..	..	..	10	35
33 Oikopleura	..	..	..	..	..	..	..	..	..	7	4	10
34 Fish eggs	10	15	12	6	3	6	2	11	6	8	7	13
35 Fish fry	3	2	7	7	8	5	4	3	5	8	8	4

TABLE V.

Fish Statistics of Ennore Estuary during 1965–66

Name of the fish.	*Total landings in kilograms.* June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Mullet	9,910	8,675	9,365	7,280	9,280	8,025	7,210	6,230	8,400	10,090	8,930	10,205
Cat-fish	7,005	5,795	8,285	4,795	7,730	6,675	4,935	3,280	4,220	6,230	6,125	9,595
Gizzard Shad	6,340	2,535	2,205	2,475	1,725	830	1,255	765	1,545	1,675	1,915	4,580
Whiting	595	1,330	3,855	4,535	735	1,750	1,985	2,670	2,525	1.895	745	155
Silverbellies	530	450	1,320	2,170	2,605	3,315	595	690	655	620	2,985	2,130
Priacanthus	5,515	1,725	430	650	3,105	5,980	3,000	1,335	1,975	1,970	2,950	4,305
Jew-fish	6,495	4,790	5,990	3,775	2,565	2,415	360	..	..	1,295	2,060	2,815
White bait	..	..	..	..	..	..	..	495	460	1,065	370	..
Half-beak	255	..	..	..	670	800	565	1,535	1,125	4,440	885	..
Gerres	1,455	1,140	1,980	3,265	820	375	205	315	580	370	455	275
Therapon	2,550	2,880	1,880	1,480	2,475	2,725	..	..	..	..	..	..
Cock-up	..	..	..	..	..	..	..	..	..	..	..	..
Eel	..	..	540	180	..	..	..	..	..	..	..	..
Teuthis	1,070	1,830	1,680	3,055	630	505	..	..	..	..	..	..
Prawn	8,820	7,315	8,435	7,400	8,710	9,565	10.585	4,065	4,705	6,980	8,460	10,625
Crabs	1,030	870	1,255	345	890	1,085	815	250	875	3,265	1,655	2,890
Other Fishes	2,985	2,630	2,470	2,220	1,265	1,145	1,000	1,545	3,120	2,795	2,830	2,365

TABLE VI.

Fish Statistics of Ennore Estuary during 1966–67.

Name of the fish.	*Total landings in Kilograms.*											
	June.	*July.*	*August.*	*September.*	*October*	*November.*	*December.*	*January.*	*February.*	*March.*	*April.*	*May.*
Mullet	11,425	7,000	8,240	7,880	6,180	4,980	5,865	9,515	8,020	10,895	10,775	15,670
Cat-fish	3,930	2,470	765	4,885	3,155	2,020	3,740	7,170	3,690	2,363	2,820	3,510
Gizzard Shad	3,735	745	250	2,295	1,860	745	2,085	5,575	3,530	6,255	1,990	1,870
Whiting	235	410	390	1,290	200	325	1,030	5,675	2,810	1,475	1,845	915
Silverbellies	1,220	375	590	770	150	130	520	825	735	920	630	920
Priacanthus	1,825	290	140	1,375	1,055	1,155	5,080	5,505	5,505	6.455	5,765	4,565
Jew fish	1,415	2,630	3,425	240	210	170	..	370	2,725	5,855	1,105	2,380
White -biat	..	..	..	1,688	462	770	870	1,220	325	295	1,495	2,955
Gerres	250	175	540	410	375	210	..	..	520	1,615	1,075	115
Therapon	1,745	335	3,620	200	270	4,130	..	..	..	..	..	..
Cock-up	..	..	..	270	..	..	..	280	855	2,540	1,190	130
Eel	..	..	..	110	140	80	..	..	..	..	..	..
Teuthis	150	310	50	240	115	400	..	..	..	..	..	..
Prawn	7,035	6,675	9,190	6,580	5,115	11,390	2,685	3,965	4,830	6,785	8,080	14,615
Crabs	2,750	1,600	1,000	770	470	215	128	485	545	1,380	1,945	1,990
Half-beak	..	..	..	..	1,335	680	920	510	1,565	1,755	820	499
Other Fishes	4,160	2,550	5,097	4,000	5,015	2,075	2,365	4,295	3,915	4,620	4.290	4.720

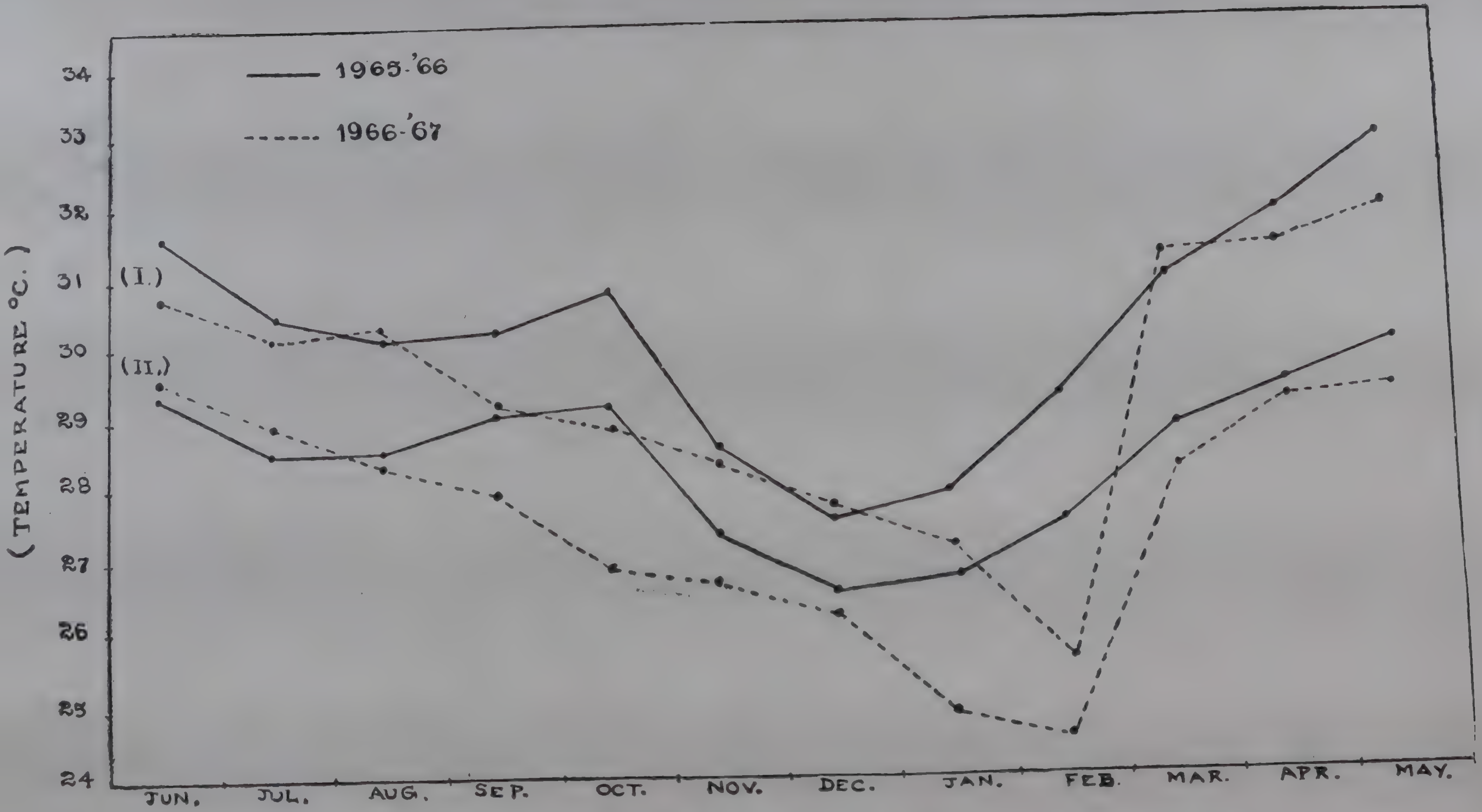


FIG. B. AVERAGE AIR (I.) AND SURFACE (II.) TEMPERATURE.

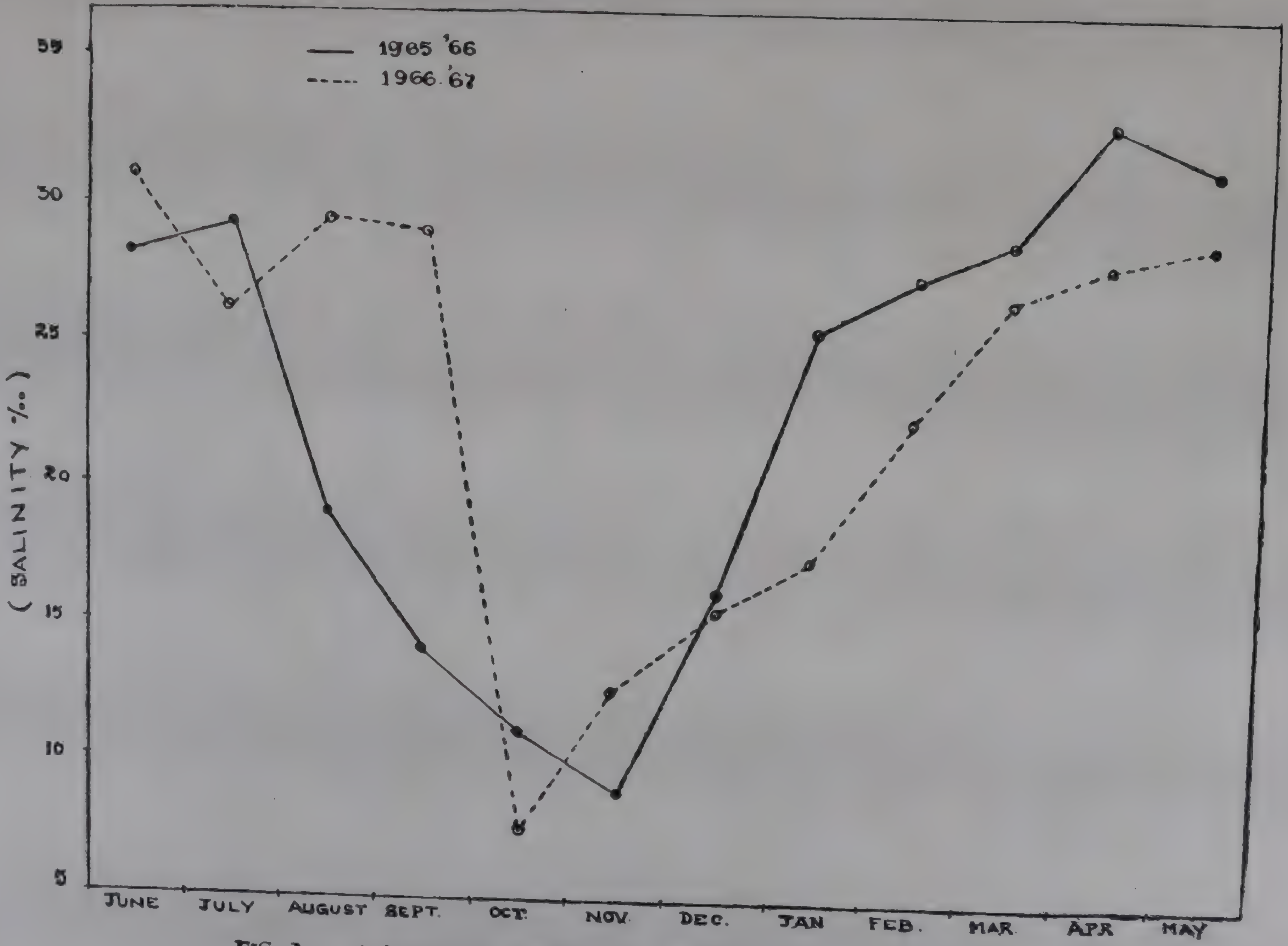


FIG. A AVERAGE SURFACE SALINITY.

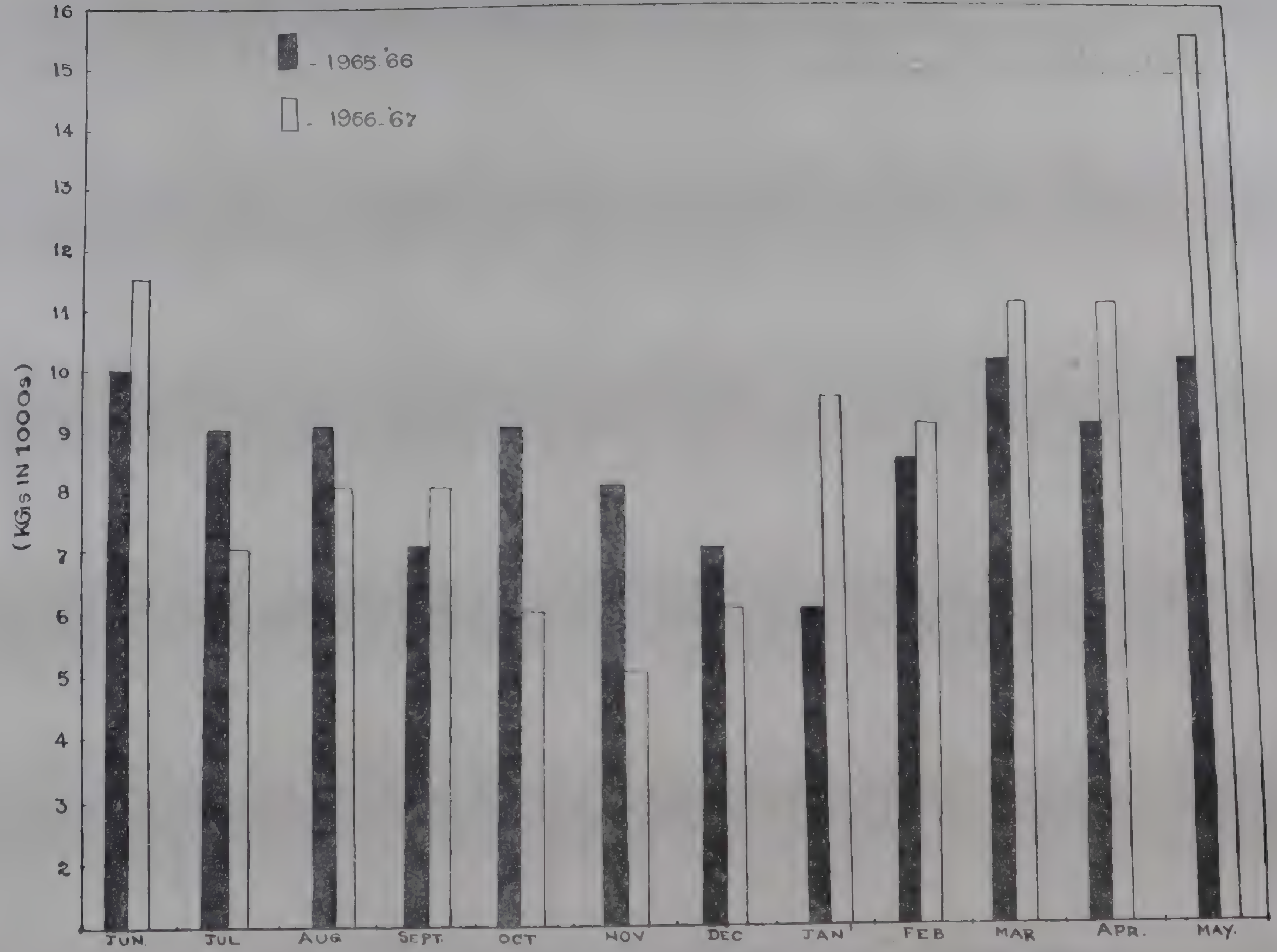


FIG C MULLET FISH LANDINGS AT ENNORE ESTUARY DURING 1965-67.

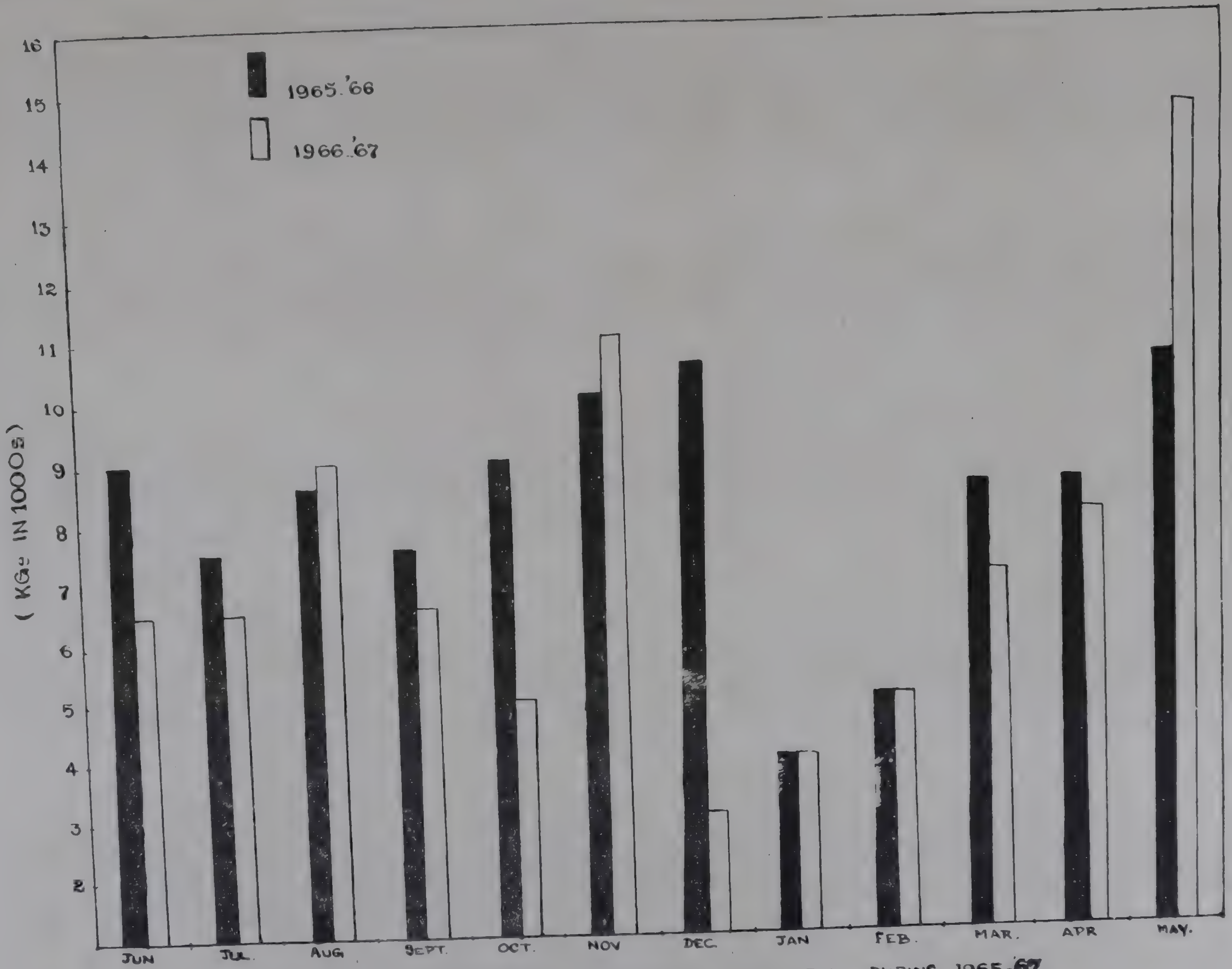


FIG. D PRAWN LANDINGS AT ENNORE ESTUARY DURING 1965-67.

PRAWN GROUNDS OFF MADRAS.

By

P. I. CHACKO and A. DANIEL.

In this note the data relating to the catches of prawns fished by the boats of the Inshore Fishing Station in the inshore waters within the 20 fathoms contour between latitudes 13·5 N and 13·25 N and longitudes 80·20 E and 80·25 E, are given. A total area of 100 square miles of numbers 13·80 C1(a), 13·80 C2(a) and (b) and 13·80 C3(b), lying opposite Pulicat, Ennore and Madras has been surveyed and found to be rich in Prawns. Details of catches made in 1965-66 and 1966-67 are given in Tables I and II. From these it may be seen that prawns are abundant in the above area during the four months from November to February. The area of concentration of prawns is within the 50 square miles portion running north to south to a stretch of 15 miles with an average width of 3 miles. The bottom is sandy from 5 to 10 fathoms, claye from 10 to 15 fathoms and of admixture of muc and clay from 15 to 20 fathoms. The fishermen having mechanised boats of stern trawler type of 30 and 32 feet size have taken full advantage of the location of the prawn resources, by operating 55, 60 and 70 feet non-overhang otter trawl nets. Some catamaran fishermen also exploit this area for prawns with their primitive midwater trawls known as *thurivalai.* The catch-effort by the stern trawl boats for prawns average 34 kg. per hour during the peak season. The common species contributing to the fishery are *Penaeus indicus* and *Metapenaeus monoceros.* More survey work has to be done, but the foundation has been laiw for prawn trawling and processing industry in Madras.

TABLE I SHOWING PRAWN LANDINGS OF BOATS ENGAGED IN THE SURVEY OF THE INSHORE WATERS OFF MADRAS COAST IN THE YEAR 1965–66.

Month.	*Number and type of boats engaged. ft.*	*Depth range in fathoms.*	*Total catches in kg.*	*Total quantity of shrimps in kg.*	*Percentage.*	*Catch effort kg./hr.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 April 1965	2 (30)	5 to 10	617·0	123·0	20	40
2 May 1965	1 (30)	5 to 10	377·0	..	..	28
3 June 1965	2 (30)	5 to 15	434·00	4·0	1	18
4 July 1965	2 (30) 1 (32)	5 to 15	2,073·0	498·0	24	48
5 August 1965	2 (30) 1 (32)	5 to 15	1,981·0	114·0	5·7	41
6 September 1965	2 (30) 1 (32)	5 to 15	4,883·0	,150·0	3	120
7 October 1965	3 (32)	5 to 20	4,435·0	174·0	4	134
8 November 1965	3 (32)	10 to 20	3,018·0	78·0	2	67·2
9 December 1965	1 (30) 1 (32)	5 to 10	509·0	..	..	9
10 January 1966	1 (30) 1 (32)	5 to 15	8,386·0	1,241·0	15	90
11 February 1966	1 (32)	10 to 15	2,766·0	725·0	26	105
2M12arch1966	1 (32)	10 to 15	2,954·0	148·0	5	10
			32,433·0	3,293·0	10·1	

TABLE II SHOWING PRAWN LANDINGS OF BOATS ENGAGED IN THE SURVEY-CUM-FISHING OF INSHORE WATERS OFF MADRAS COAST IN 1966–67.

	Month.	*Number and type of boats.* FT.	*Depth range in fathoms.*	*Total catches in kg.*	*Total quantity of shrimps in kg.*	*Percentage.*	*Catch effort. kg./hr. (prawns)*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	April 1966	3 (30) 3 (32)	5 to 19	898·0	21·0	2·4	9
2	May 1966	3 (30) 2 (32)	6 to 18	1,371·0	200·0	14·5	14
3	June 1966	3 (30) 3 (32)	8 to 18	5,612·5	58·5	1·0	35
4	July 1966	3 (30) 2 (32)	12 to 18	7,409·0	54·5	0·7	53
5	August 1966	3 (30) 3 (32)	5 to 15	8,314 0	9·0	0·1	45
6	September 1966	2 (30) 3 (32)	6 to 16	1,503·0	167·0	11·1	23·5
7	October 1966	2 (30) 1 (32)	5 to 12	1,313·0	54·5	4·1	34
8	November 1966	2 (30) 1 (32)	5 to 10	2,033·0	271·5	13·3	7
9	December 1966 ..	2 (30) 3 (32)	5 to 14	6,217·0	1,422·5	22·8	39
10	January 1967	3 (30) 3 (32)	6 to 14	5,228·0	1,070·0	20·4	33
11	February 1967	2 (30) 3 (32)	5 to 14	8,356·0	1,163·0	13·9	39
12	March 1967	2 (30) 3 (32)	6 to 19	2,408·0	71·0	2·9	26
				47,863·0	4,562·5	9·5	

A NOTE ON COPEPOD PARASITES IN FISH OF THE VELLAR ESTUARY AT PORTONOVO.

By

Thirumathi GEMMA EVANGELINE and Thiru V. VENKATESAN, Research-*cum*-Survey of Estuaries Station, Portonovo.

Introduction

A study of the fishery of the Vellar estuary was taken up from October 1966. About 45 species of estuarine and marine fish were recorded. Most of the species of fish landed were found infested with Copepod parasites. They were found on the gill pouch, gill filaments, pectoral peduncle and dorsal fins of nearly 85 per cent of the fish examined. While certain species of the Copepod parasites were recorded every month, others were found to be seasonal occurring abundantly when a particular fishery was at its peak. Some rare forms were available with no particular seasonal preference. The present note deals with six species of parasitic Copepods belonging to the genera, Thysanote, *Lepeophtheirus*, *Caligus*, *Ergasilus*, *Pseudobomolochus* and *Bomolochus* found on a few species of estuarine fishes collected at Portonovo.

1. *Order.—Lerneopodidea.*
   Family.—Lerneopodidae.
   Genus.—Thysanote.
   Species.—Thysanote species.

Material.—A number of specimens of females which were collected from 278 *Mugilcunnesius* were examined.

Remarks.—Between seventh January 1967 and first April 1967 a total number of 672 Mugil cunnesius were examined, out of which 278 were found to be infected with this parasite. They were attached invariably to the ventral aspect of the pectoral peduncle. In most of the fishes the parasites occurred on both the sides. The percentage of incidence ranged from 11 per cent to 76 per cent. All the parasites collected were gravid females. Out of 278 parasitised fish specimens examined, 261 fish had females carrying two egg cases, while the remaining carried only one.

In the female, the cephalothorax is short, flattened dorsoventrally, indistinctly demarcated from the trunk and slightly bent ventral wards. The trunk is wide behind. The first maxillipedes united only at the tip, forming a small mush room shaped bulla. Each maxillipede bears two pairs of digitiform processes, originating from the middle of the ventral side. The posterior part of the trunk differs from that of *Thysanote appendiculata* in having only two pairs, that is one dorsal and one ventral pair of lateral processes. No anal laminae are present. Egg sacs are long and cylindrical.

Total length.—4·6 m.m.
Length of Egg sac.—1·6 m.m.

2. *Order.—Caligidea.*
   Family.—Caligidae.
   Sub-Family.—Lepeophtheirinae.
   Genus.—Lepeophtheirus.
   Species.—Lepeophtheirus species.

Material.—Parasitic females were found infesting two *Mugil cunnesius* and were examined.

Remarks.—The place of attachment was always on the inner part of the operculum. These parasites are of fairly large size. Out of the 71 fishes examined only two were found to be infested by this parasite. The percentage of incidence rarely exceeds 3 per cent. Noteworthy features of this genus are: (1) The head is fused with the first three thoracic segments and is covered with a carapace; (2) Caudal rami are short and wide, (3) egg strings are uniseriate and often longer than body; This parasite is found to be generally parasitic on marine teleosts. This parasite resembles in structure *L. Eurus* described by Bere (1936) in *Carcharias limbatus.*

Total length.—5·3 m.m.
Length of egg sac.—2·3 m.m.
Length of Cephalothorax.—1·7 m.m.
Length of trunk.—1·1 m.m.

3. *Order.—Caligidea.*
   Family.—Caligidae.
   Genus.—Caligus.
   Species.—Caligus (alatus).

Material.—Parasites collected from three specimens of *Mugil parsia* were examined.

Remarks.—They inhabit the inner side of the operculum. Out of a total number of 116 fishes examined three were found infested by these parasites. All the parasites collected were females bearing two egg cases. The parasite resembles *Caligus alatus* described by Heegaard (1943) in *Canthidermus maculatus* :

Carpace is orbicular ; Eggs are uniseriate ; Egg strings are longer than the entire body. They are found to be parasitic on marine teleosts and elasmobranchs.

Total length.—3·9 m.m.

Length of Cephalothorax.—1·7 m.m.

Length of trunk.—1·4 m.m.

Length of egg sac.—0·8 m.m.

4. *Order.—Cyclopidea.*

Family.—Ergasilidae.

Genus.—Ergasilus.

Species.—E. orientalis.

Material.—Parasites examined were found attached to the gill filaments of *Ambassis commersoni.*

Remarks.—The body is cyclopoid in form. The head is fused with the first thoracic segment. Other thoracic segments are also indistinct. Abdomen consists of four segments ; second antenna is strongly prehensile with the terminal segment forming a stout claw ; which has no accessory claw ; Egg sac is plump, containing numerous eggs. Percentage incidence is approximately 27 per cent.

It resembles *Ergasilus orientalis* described by Yamaguti (1939) in *Acanthogobius flavimanus.* All the 88 parasites collected were gravid females bearing two egg cases.

Total length.—1·1 m.m.

Length of Cephalothorax.—0·6 m.m.

Length of trunk.—0·2 m.m.

Length of egg sac.—0·5 m.m.

5. *Species.—Pseudobomolochus multispinosus.*

Material.—The parasites were found in the gillpouch of *Gerromorpha filamentosa.*

Remarks.—About a hundred fishes were examined for these parasites. Of these about 27 fishes were found to be infested with this parasite. Normally these parasites occur in the gill pouch on one side only and is rarely found on both the sides. All the specimens examined were gravid females carrying a pair of eggs.

The body is cyclopoid. The head is fused with the first thoracic segment and is enlarged. It is provided dorsally with a sclerotized median rib. The first antennae is six segmented. The basal segments are fused and fringed with a row of palmose setae;

It is found to be parasitic on marine teleosts, and resembles *Pseudobomolochus multispinosus* described in *Dussumieria acuta* by Gnanamuthu (1949). An armed chitinous plate is present dorsal to the base of first antenna.

Total length.—2·1 m.m.

Length of Cephalothorax.—0·8 m.m.

Length of trunk.—0·3 m.m.

Length of egg sac.—1·0 m.m.

6. *Order.—Cyclopidea.*

Family.—Bomolochidae.

Genus.—Bomolochus.

Species.—Bomolochus species.

Material.—Parasites found on 11 specimens of *Mugil parsia* were examined.

Remarks.—This parasite was found attached to the gill filaments of *Mugil parsia.* In a total number of 51 fishes examined, only 11 fishes were found to be infested by this parasite. It is usually present on one side only. Percentage incidence is 22 per cent. All the parasites examined were females carrying a pair of egg cases.

The body is cyclopoid. The head is fused with the first segment and is enlarged. The rest of the body tapers backward rapidly. The genital segment is enlarged. The first antenna is six segmented of which the three basal segments are fused, widened and fringed with a row of flattened setae. It is without an armed chitinous plate dorsal to the base of first antenna. It is found to be parasitic on the gills of fresh water and marine fishes. One species has been recorded in Indian fishes, namely *Bomolochus acutus* by Gnanamuthu (1948) on *Dussumieria acuta.* Wilson (1911) has recorded another species *Bomolochus concinnus* in *Mugil Cephalus.* The specimen obtained from Mugil parsia does not resemble either of them.

Total length.—2·2 m.m.

Length of Cephalothorax.—0·8 m.m.

Length of trunk.—0·32 m.m.

Length of egg sac.—1·0 m.m.

Identification of the parasites described above, further, to fix up the species is in progress.

References.

1. Bere, R. (1936). Parasitic Copepods form Gulf of Mexico. Fish Am. Midl. Nat 17 (3) 577-625.

2. Gnanamuthu, C. P. (1948) Bomolochus acutan species a Copepod parasitic on the gills of Dussumieria acuta. Proc. Ind. Acad. Sc. Sect. B 27 (1) 18-25.

3. Gnanamuthu, C. P. (1949) Pseudobomolochus multispinosa species Nov., an Ergasilid copepod observed in copulation. Rec. Ind. Mus. 45(4) 1947, 291-298.

4. Gnanamuthu, C. P. (1950) Thysanate appendiculata (Steenstrup at Lutken) a Lernaeopodid parasitic on the gills of the grey pomfret. Parasitology 39 (3-4) 209-213.

5. Heegard, P. (1943) Some new caligids from the Gilbert Islands. Ark. Zool. 34 A (16), 12 pp.

6. Wilson, C. B. (1911) North American parasitic copepods, Description of New genera and species. Proc. U.S. Nat. Mus. (1788) 39 263-400.

7. Yamaguti, S. C. (1939) Parasitic copepods from fishes of Japan. Part 4. Cyclopoida II Vol. Jub. Yoshida 2, 391-441.

AN INSTANCE OF LARGE SCALE PARASITISM OF SACCULINA ON THE EDIBLE CRAB NEPTUNUS PELAGICUS.

By

P. S. SAMBANDA MURTHY and P. I. CHACKO.

An examination of trawl net catches made near Tuticorin Light House Island (Gulf of Mannar) on 16th March 1962, revealed large-scale parasitism of the edible crab *Neptunus pelagicus*. The total number of these crabs in the catch was 75, out of which 25 were with the parasite, *Sacculina*. Thus the percentage of crabs infected by the parasite was 33. Out of the 25 parasitised crabs four were with two parasites.

Instances of large scale parasitism on crabs seem to be rare. Nayar (1956) noticed in a collection of 193 crabs (*Neptunus sanguinolentus*) caught off the Ramanathapuram on 6th February 1956, 169 parasitised crabs, the percentage being even greater than the present instance. He also noticed that 73 of the affected crabs had two parasites and five had three parasites on a single host. In a previous instance George (1948) noticed in a female crab two parasites belonging to the genus *Sacculina*. He further observed that the place of attachment of the parasites was on the third and fourth abdominal segments. But Nayar (1956) observed that there is no regularity regarding the exact point of emergence of the parasite on the abdomen of the host. Our present observation concur with the former in that most of the parasites were found attached to the third and fourth segments of the abdomen only, as shown in the accompanying table. It is noteworthy that all the parasitised crabs in this case also were females only as observed by Nayar (1956). Another feature in this case is that out of the twenty-five parasitised crabs sixteen were with their carapace encrusted with the acorn barnacle, *Balanus sp.*

---

1. Nayar, N. B. (1956): Journ. Bombay Nat. Hist. Soc. pp. 731-732.

2. George, M. J. (1948): Proc. Ind. Acad. Sci., B: 207.

TABLE SHOWING DETAILS OF THE PARASITIC INFESTATION IN 25 CRABS.

Serial number. (1)	*Sex of crab.* (2)	*Breadth of carapace of crab.* (3)	*Number of parasites.* (4)	*Number of the segment of the abdomen on which parasite is found.* (5)	*With or without Balanus.* (6)
		MM.			
1	Female	100	1	3	Present.
2	Do.	101	1	3	Do.
3	Do.	102	2	3 and 4	Do.
4	Do.	105	1	3	Do.
5	Do.	110	1	3	Absent.
6	Do.	105	2	3 and 4	Do.
7	Do.	92	1	3	Present.
8	Do.	110	2	3 and 4	Do.
9	Do.	103	1	3	Do.
10	Do.	111	1	3	Do.
11	Do.	110	1	3	Do.
12	Do.	124	1	3	Absent.
13	Do.	90	1	3	Do.
14	Do.	115	2	3 and 4	Present.
15	Do.	95	1	3	Absent.
16	Do.	90	1	3	Present.
17	Do.	97	1	3	Do.
18	Do.	88	1	3	Do.
19	Do.	100	1	3	Do.
20	Do.	83	1	3	Absent.
21	Do.	75	1	3	Do.
22	Do.	114	1	3	Present.
23	Do.	95	1	3	Do.
24	Do.	111	1	3	Absent.
25	Do.	80	1	3	Do.

A STUDY OF THE STRUCTURAL COMPONENTS OF THE ADHESIVE DISC. OF ECHENEIS (ARTEDI) AND THEIR FUNCTIONS.

PART II—SKULL AND FIRST FIVE VERTEBRAE.

By

B. BONNELL and Mrs. JEYACHANDRAN.

Introduction.

Part I of this article which appeared in Vol. III of the Madras Fisheries Journal in January 1967 described the externals of the sucker and the skeletal pieces found in the disc in detail. But since the functions appear to be closely connected with the movements of the head and the first five vertebrae and can be understood only if a detailed knowledge is presented, there seems to be no other alternative but to describe them here.

The skull.

Fig. 1 is the dorsal view of the skull after the adhesive disc has been removed and the surface cleared of all muscular tissues situated on it. Every bone was painted in colour before the photograph was taken and so the limits are clear. The lower jaw projecting in front has been omitted.

The premaxillae are provided with several rows of teeth of which the front row has a tendency to project forwards. There is a gap between the teeth where the premaxillae are joined by softer tissue. Behind the premaxillae and between them and the vomer an opening is shown in the drawing. This is covered by a movable rostral cartilage which probably acts as a valve. The maxillae border the premaxillae on their inner side and have no teeth. Above the maxillae two pairs of supramaxillae are present. The nasal is median in position and separates the fused frontoparietals for part of their length. The vomer which really is a ventral median bone has a transverse ridge peeping in front of the nasal. The supra orbitals bound the cavity of the eyes above. The supra occipital does not seem to share in the formation of the foramen magnum. It is bordered by the exoccipitals at the sides and the basioccipital below. The other dorsal bones are the post parietals and the epiotics and the pterotics. The sphenotics normally ventral in position peep out at the sides.

Fig. 2, is the ventral view of the skull with the lower jaw removed. The innumerable teeth distributed on the premaxillae are distinct and between them a gap of soft tissue is present. When the teeth of the upper and lower jaw interlock an opening will still remain between the teeth. The gap between the premaxillae and the large vomer is covered by the rostral cartilage dorsally which has been removed here. The Parasphenoid seems to be the biggest ventral bone occupying the greater part of the cranium. The entire ventral surface is paved with bone but for a gap immediately behind the premaxillae covered by the valvular rostral ethmoid cartilage dorsally and enclosed in a thin bag of tissue. The other bones in the ventral view are the median basioccipital the paired prootics, Sphenotics, pterotics and opisthotics. Some of the dorsal bones such the supraorbitals frontoparietals and nasal are visible on the ventral side as well.

Figure 3 is a lateral view of the skull of Echeneis after the adhesive disc has been removed with the lower jaw, the operculum and the pectoral girdle in tact. Every bone is named and can be recognised from the picture.

The Vertebrae.

Plate I Figs. A-F., represent various views of the first vertebra, the Atlas. Figure A, shows the articular surfaces for the condyles of the skull, the neural arch with the large neural canal for the spinal cord and the supra neural canal which is very much smaller. The neural spine is not formed as a distinct structure. Transverse processes are present eventhough the Atlas in the human being does not have them.

Fig. B, shows that the neural arch is extended forwards and backwards to overlap the skull in front and the vertebra behind. The clear round opening O, serves as an exist for the spinal nerve of the segment.

Fig. C, shows that the transverse processes project backwards. In Fig. D, the supraneural canal is separated from the neural canal by a constriction which in life has a partition across it. Figure E. shows that the centrum has a thick hind end and a narrow front one with articulating surfaces for the condyles.

The second vertebra figured in G-L shows that the transverse processes project outwards instead of backwards as in the atlas. The neural and subneural canals are distinct. The sides of the neural arch touch each other but a distinct neural spine is not formed. The Zygapophyses for attachment of one vertebra to the next are seen. The neural arch has not come together in front. This is because the space is occupied by the prolongation of the Atlas behind. In the hind region the neural arch overlaps the centrum and is extended to the next vertebra. The centrum is amphicoelous. The side views show the large opening for the exit of the spinal nerves. There are smaller apertures also present but they lead into the supraneural canal and evidently are connected with the supply of fluid to it.

Vertebrae three, four and five are similar to the second to a great extent. In every case the transverse processes point outwards. The neural arch has a gap in front to accommodate the posterior prolongation of the neural arch of the previous vertebra. Numerous small apertures are present which lead into the supra neural canal and supply the necessary liquid requirements. The neural spine is progressively being formed and in the fifth vertebra the structure appears as an elongated pointed rod as seen in figures Q and R.

Examining the vertebral column we notice that the transverse processes are longest in the fifth vertebra which marks the posterior limit of the adhesive apparatus. They then tend to decrease in size. On the other hand the neural spine continues to lengthen out and in the region of the dorsal fin behind, provide surfaces for the attachment of the proximal segments of the fin rays.

Summary.

This article. by figures 1, 2 and 3, prominently brings before the eye the chief bones involved in the structure of the skull to enable us to understand the functioning of the adhesive disc which will be described later.

The two illustrative plates with their figures from A to R. Similarly present various views of the first five vertebrae directly below the adhesive disc.

Acknowledgments.

This research is being pursued with a generous grant from the C.S.I.R. in the laboratory of the New College, Madras-14 by the kindness of the Principal and the Management and we are grateful to all of them. The Director of Fisheries, Madras, has provided us with some more dead specimens for which we thank him. We hopefully look forward to the opportunity of examining live specimens promised in the Aquarium at an early date. Dr. M. Dharmarajan has been kind enough to read through the manuscripts and suggest corrections.

References.

Starks, E. C.—Bones of the ethmoid region of the fish skull. Standford University publications. Biological Sciences, Vol. IV No. 33, p. 296.

Godrich, E. S.—Studies from the Structure And Development Of Vertebrates, Vol. I, pp. 283-303.

Messer. Vertebrate Anatomy. pp. 186-188.

Romer, The Vertebrate Body, pp. 192-193.

Viswanath, A Text Book of Zoology, Vol. II, pp. 214-227.

List of Illustrations.

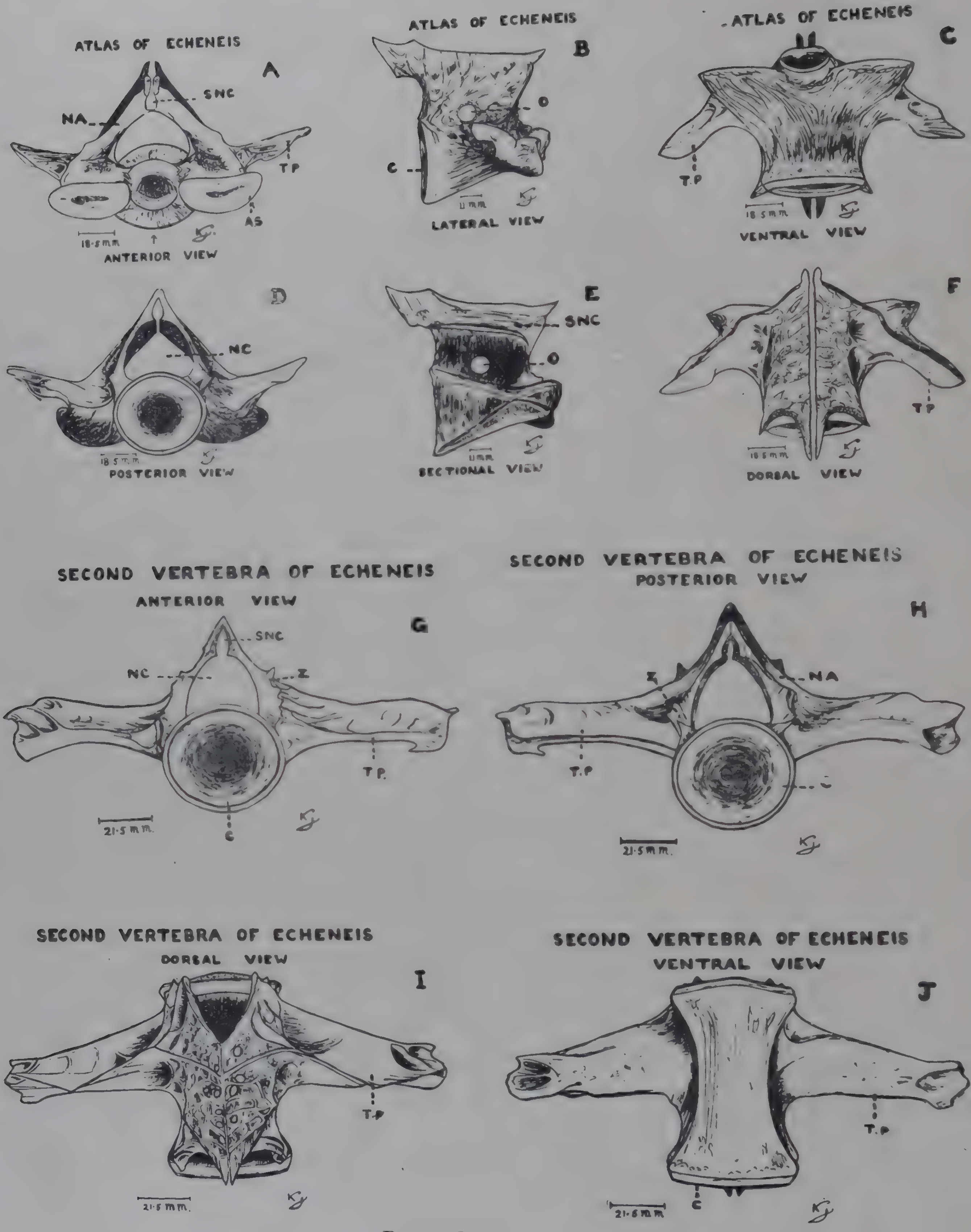
1. Dorsal view of the skull of Echeneis.
2. Ventral view of the skull of Echeneis.
3. Lateral view of the skull of Echeneis.

Plate I, Vertebrae one and two of Echeneis.

A, Anterior view;
B, Lateral view;
C, Ventral view;
D, Posterior view:
E, Sectional view;
F, Dorsal view Second Vertebra;
G, Anterior view;
H, Posterior view;
I, Dorsal view;
J, Ventral view.

Plate II—Vertebrae two to five Second Vertebra:

K, Lateral view;
L, Sectional view; Third vertebra;
M, Dorsal view;
N, Ventral view; Fourth vertebra:
O, Dorsal view;
P, Ventral view; Fifth vertebra;
Q, Dorsal view;
R, Ventral view.



ATLAS OF ECHENEIS

ANTERIOR VIEW

ATLAS OF ECHENEIS

LATERAL VIEW

ATLAS OF ECHENEIS

VENTRAL VIEW

POSTERIOR VIEW

SECTIONAL VIEW

DORSAL VIEW

SECOND VERTEBRA OF ECHENEIS

ANTERIOR VIEW

SECOND VERTEBRA OF ECHENEIS

POSTERIOR VIEW

SECOND VERTEBRA OF ECHENEIS

DORSAL VIEW

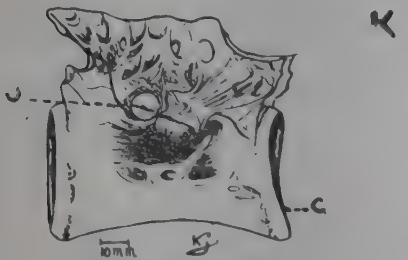
SECOND VERTEBRA OF ECHENEIS

VENTRAL VIEW

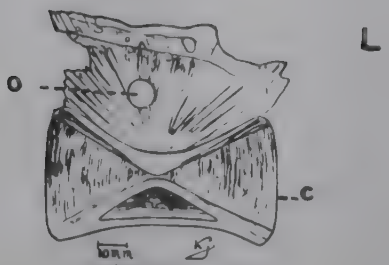
A
SNC
NA
TP
AS
18·5mm
B
O
C
11mm
C
T.P
18·5mm
D
NC
18·5mm
E
SNC
O
11mm
F
TP
18·5mm
G
SNC
NC
Z
T.P.
C
21·5mm
H
Z
NA
T.P
C
21·5mm
I
T.P
21·5mm
J
T.P
C
21·5mm

PLATE I

SECOND VERTEBRA OF ECHENEIS

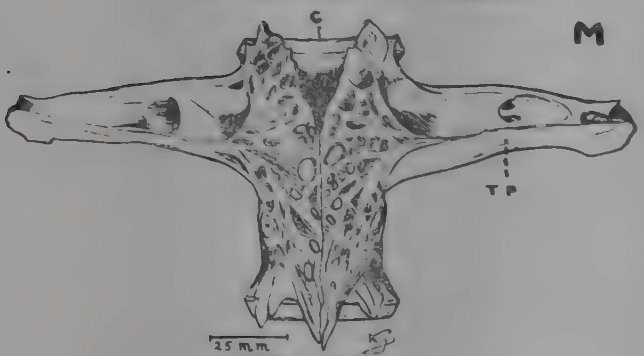


LATERAL VIEW



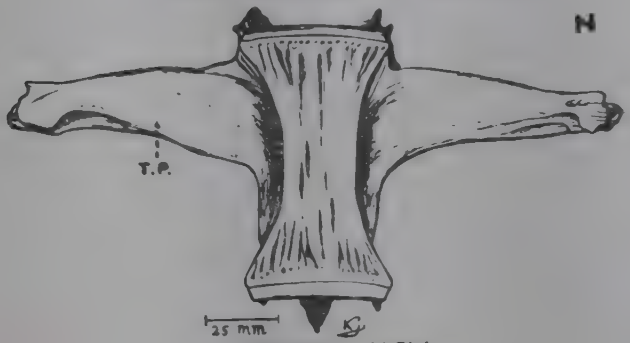
SECTIONAL VIEW

THIRD VERTEBRA OF ECHENEIS

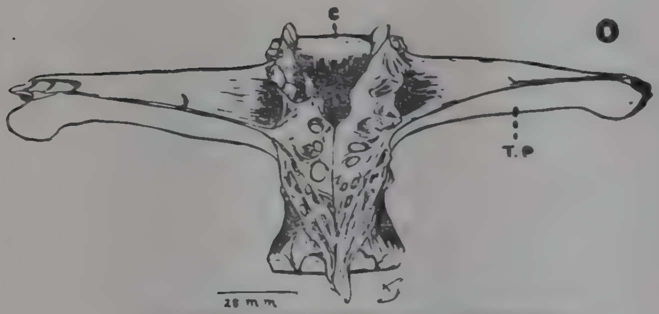


DORSAL VIEW

THIRD VERTEBRA OF ECHENEIS



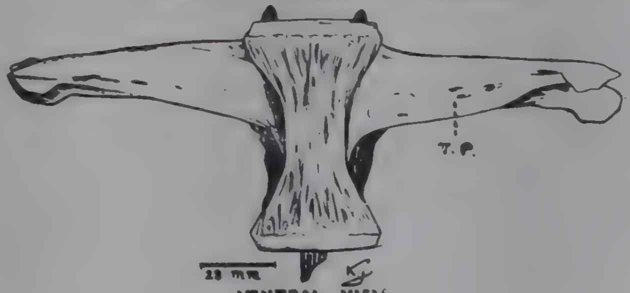
VENTRAL VIEW



FOURTH VERTEBRA OF ECHENEIS

DORSAL VIEW

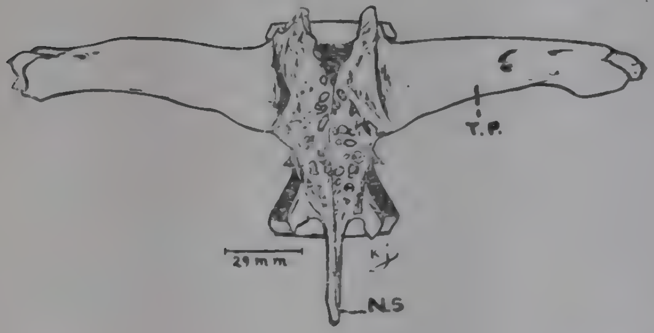
FOURTH VERTEBRA OF ECHENEIS



VENTRAL VIEW

FIFTH VERTEBRA OF ECHENEIS

DORSAL VIEW



FIFTH VERTEBRA OF ECHENEIS

VENTRAL VIEW

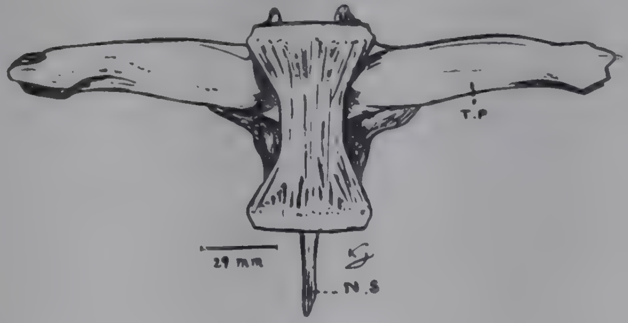


PLATE II

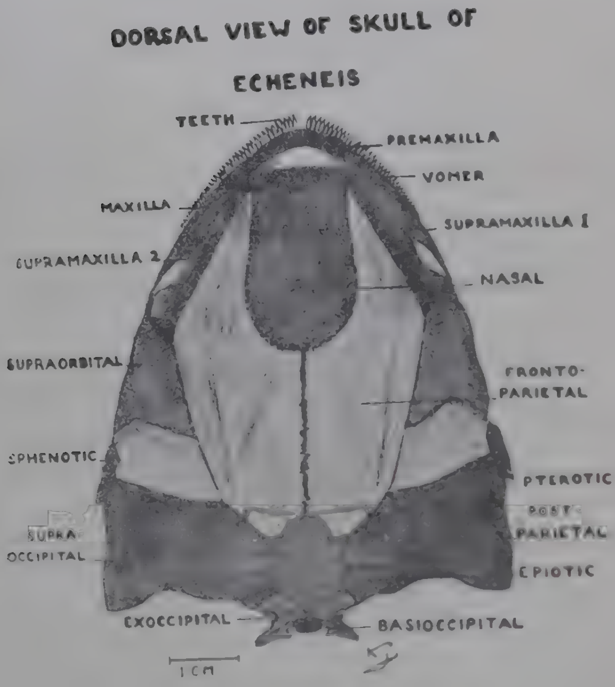

DORSAL VIEW OF SKULL OF
ECHENEIS
TEETH
PREMAXILLA
VOMER
MAXILLA
SUPRAMAXILLA 1
SUPRAMAXILLA 2
NASAL
SUPRAORBITAL
FRONTO-PARIETAL
SPHENOTIC
PTEROTIC
POST-PARIETAL
SUPRA-OCCIPITAL
EPIOTIC
EXOCCIPITAL
BASIOCCIPITAL
1 CM

Fig 1

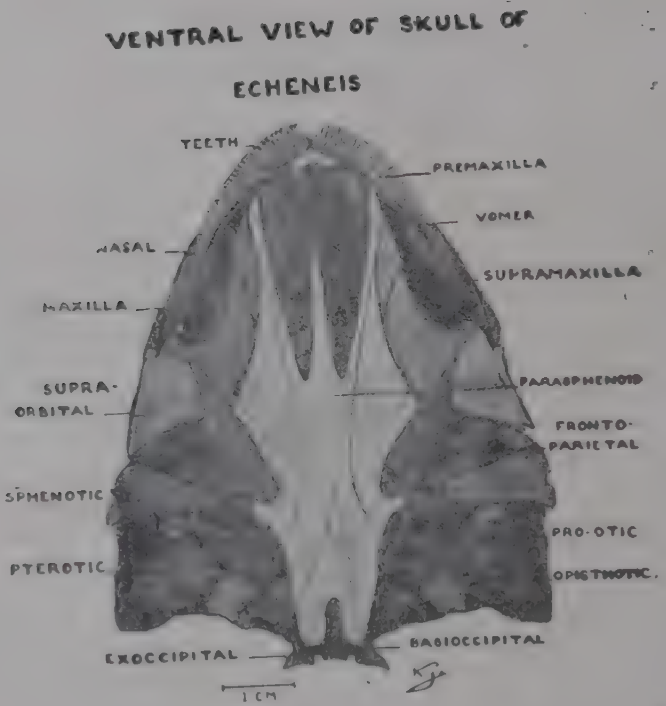

VENTRAL VIEW OF SKULL OF
ECHENEIS
TEETH
PREMAXILLA
VOMER
NASAL
SUPRAMAXILLA
MAXILLA
PARASPHENOID
SUPRA-ORBITAL
FRONTO-PARIETAL
SPHENOTIC
PRO-OTIC
PTEROTIC
OPISTHOTIC
BASIOCCIPITAL
EXOCCIPITAL
1 CM

Fig 2

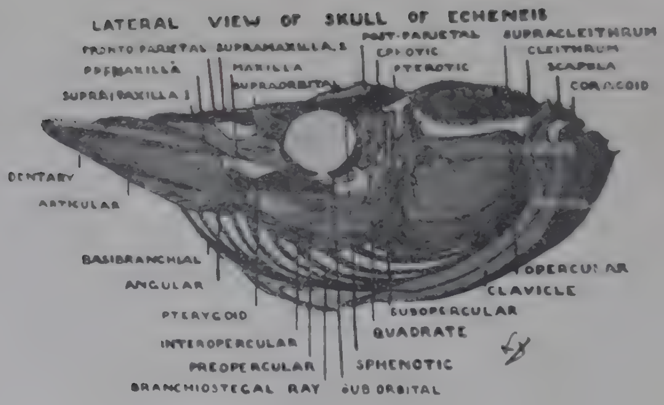

LATERAL VIEW OF SKULL OF ECHENEIS
POST-PARIETAL
SUPRACLEITHRUM
FRONTO PARIETAL
SUPRAMAXILLA 2
EPIOTIC
CLEITHRUM
PREMAXILLA
MAXILLA
PTEROTIC
SCAPULA
SUPRAORBITAL
CORACOID
SUPRAMAXILLA 1
DENTARY
ARTICULAR
BASIBRANCHIAL
OPERCULAR
ANGULAR
CLAVICLE
PTERYGOID
SUBOPERCULAR
QUADRATE
INTEROPERCULAR
PREOPERCULAR
SPHENOTIC
BRANCHIOSTEGAL RAY
SUB ORBITAL

Fig 3

THE ORAL BREATHING VALVES OF ECHENEIS FISHES AND THEIR PROBABLE INFLUENCE ON THE MOVEMENTS OF THE COMPONENTS OF THE ADHESIVE DISC.

By

B. BONNELL and Mrs. K. JEYACHANDRAN.

Introduction.

Samuel Collins recognised the presence of valves attached to the maxillae and mandibles in Holybut (Halibut) as early as 1685. Ulric Dahlgren in 1898 described the valves and their functioning by means of suitable diagrams in the Sunfish *Eupomotis gibbosus.* In 1904 seventy species of Teleostean fishes were studied by Evelyn Grossbeeck Mitchell and their breathing valves classified according to their shapes. In 1935 Gudger provided a very complete list of all literature on oral breathing valves taking care to draw attention to brief incidental references buried in general works on comparative anatomy and physiology. The valves have been recorded for 150 teleosts and probably are present in others as well.

Our interest is in the statement by Mitchell recorded thus: "In *Echeneis naucrates* where the mouth is truly superior there is a small maxillary valve whose greatest width is on the parts each side of the meson about half way to the ends. This also can be accounted for by the hollowing out of the roof of the oral cavity".

Description.

When the front portion of Echeneis is slit laterally along one side and spread out so as to make it possible to examine the buccal cavity, the following points present themselves. *(Vide figure 1.)* The upper jaw is short. It has rows of teeth arranged all along the premaxillae but for a very small gap in between consisting of soft sensory tissue. The lower jaw is elongated far beyond the upper and is provided with areas covered with pointed teeth all along the dentary. The front end however is completely free of them and a soft sensory tissue is noticeable which is continued backwards into a passage which enters the mouth. The maxillary passage is however narrower than the mandibular one. The two passages would imply that when the jaws are closed the teeth can interlock and yet between them a channel can be formed through which water can enter the mouth. It looks as though it is necessary that water should continue to enter the mouth at all times.

Water circulation.

On entering the mouth the water is directed to its proper destination by the oral breathing valves. The maxillary breathing valves are narrower than the mandibular and direct the water stream over the anterior border of the vomer so that it enters the buccal cavity. The mandibular on the other hand is broader and has to see that the water passes over the basihyal of the visceral-arch so that it might pass out to the subopercular chamber later. If this is not done it might be that the water tries to enter the pharynx from the subopercular chamber to the inside and would not succeed as the tendency will be for the visceral arches to come together preventing ingress.

Next the buccal cavity diminishes in size by the vomer of the upper jaw and the basihyal of the lower trying to touch each other. Part of the water will attempt to get out through the mouth but will be prevented by the breathing valves coming together. Pressure will be formed below, the valves and the water directed backwards. The rest of the water will naturally enter the pharyngeal region. One important fact to remember is that while the roof of the mouth is practically paved with bone there is a gap covered by tissue between the vomer and the premaxilla. Just over the gap the movable rostral cartilage is present. It cannot but be influenced by changes in pressure below it. Because the rostral cartilage has been described as influencing movements of the disc of *Echeneis* we have to come to the inevitable conclusion that branchial movements influence the disc and *vice versa.*

The water which has reached the pharyngeal region will be forced to get out by the approximation of the pharygobranchials and the fifth branchial arch which is represented as broad plates. Most of the water enters the branchial clefts to get to the subopercular region and perhaps a small quantity enters the oesophagus. When the operculum is raised water will try to enter it either from within the pharynx or from the outside. The branchiostegal rays of the operculum which are connected with each other by tissue, form valves which prevent water from entering the subopercular chamber. So water can get in only from the pharynx. When the operculum is lowered the pharyngeal gill clefts come together preventing water from entering it. The branchiostegal valve opens and water is discharged to the exterior.

Water flows in one direction, i.e., mouth-buccal cavity-pharynx-suboperculum and then to the outside below the branchiostegal valves. Respiration in the frog is reversible because air with a good supply of oxygen enters the lungs but has to be sent back in the reverse order laden with carbondioxide. This reversal is unnecessary in the fish.

Summary.

Echeneid fishes possess highly sensory discs capable of constant movement of their components producing bionic waves to obtain information from their sorroundings.

The oral breathing valves in addition to helping in respiration communicate movements als to the disc and can therefore be said to help i the information probing function of the disc.

Acknowledgments:

This research has been carried out by us with a grant from the C.S.I.R. to whom we ar indebted. The management and the Principa of the New College, Madras, have continued t give us all facilities for our work for which w are greateful. Dr. M. Dharmarajan has kindly read through this manuscript and made some corrections.

References.

Collins Samuel, 1685 "On the Palate of Man And Other Animals" A System of Anatomy. London, Vol. 1, Part (ii), Chapter 5.

Galton, 1871 'How Fishes Breathe' Popular Scientific Review, No. 10, pp. 342-343.

Dalhgren Ulric, 1898. The maxillary and mandibular breathing valves of teleostean fishes. Zoological Bulletin. Vol. 2, pp. 117-124.

Mitchell, E. G. 1904 "Oral Breathing Valves of Teleosts" American Naturalist, Vol. 38, pp. 153-164.

Gudger, E. W. 1935. "Oral Breathing Valves in Fishes" Amer. Mus. Nat. Hist., Vol. 79, pp. 263-285.

Also all papers by the present author in Nature. Vol. 191, p. 403; Vol. 196, pp. 1114-1115; Vol. 203, p. 208 and Vol. 212, pp. 736-737.

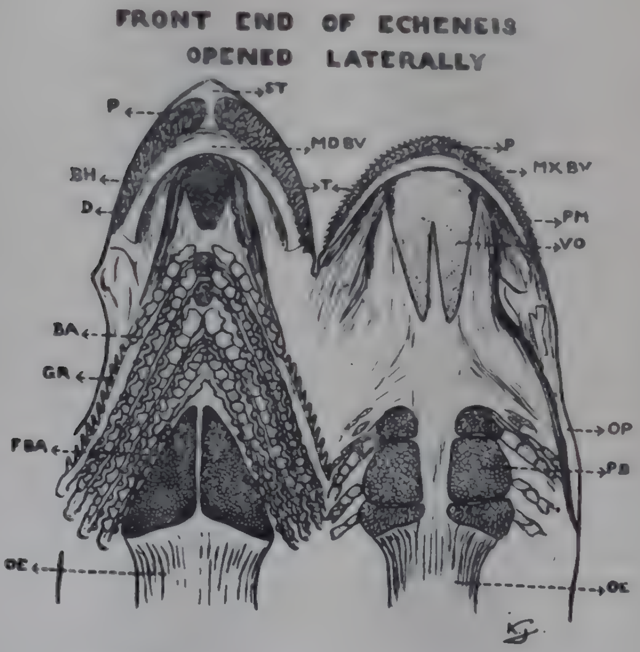


Figure 1 Front end of Echeneis opened laterally. BA, Branchial Arch; BH, Basihyal; D, Dentary; GR, Gill rackers; FBA, Fifth banchial arch; MDBV, Mandibular breathing valve; MXBV, Maxillary breathing valve; OE, Oesophagus; OP, Operculum; P, Passage between teeth; PB, Pharygobranchial; PM, Premaxilla; ST, Soft tissue; T, Teeth; VO, Vomer.

OBSERVATIONS MADE ON A LIVING SUCKER FISH ECHENEIS (Sp.)

By

B. BONNELL

Through the kindness of Sri A. Padmanabhan, I.A.S., Director of Fisheries, Madras, the first opportunity to observe a small sucker fish about 25 cms. long in the living condition came on the 13th of October 1967. The specimen was brought to the Government Aquarium the previous day and accommodated in a brightly illuminated tank along with small fish of the general Tl rapon and Acanthurus. The glass tiled roof of the tank enabled direct sunlight to enter and the fish was brightly illuminated.

While swimming the graceful harmonic movements from side to side, two distinct white bands the upper of which bordered the upper jaw, passed over the eye and was continued right up to the caudal fin slightly entering it, and the lower one passing below the lower jaw and reaching the vicinity of the caudal fin, were distinctly visible. Between the two white bands the region by contrast was very dark. The Caudal fin had two independant white bands one above and one below. They were not continuations of the lateral white bands. The dorsal side was darkish and definitely less dark than the sides. The ventral surface was also dark to a lesser degree.

On the first day the fish was vigorous, did not think of attaching itself anywhere and rested on the bottom with dignity. The front region from the position of the pelvic fins was raised at an angle of say 35 ° and kept in the same position all the while. This probably was a necessity because the operculum on the under side of the head had to be constantly moved while allowing water which entered the mouth to get out.

The part of the body between the pelvic fins and the anus rested on the ground but thereafter the long tail was not in contact with it but was raised. The caudal fin was spread vertically and lifted from the ground only occasionally touching it. In the side view the appearance was that of a modern elongated aeroplane at rest. The pectoral fins of the fish project outwards and move freely up and down while swimming. The pelvic fins on the other hand are attached at an angle and project downwards when spread out.

The fish when it wishes to rest, elegantly folds its pelvic fins by drawing the rays of the fins together reminding us of the way in which the under carriage of an aeroplane is withdrawn.

While resting on the ground the movements on the adhesive disc are not clear, but it cannot be said that they do not move at all for the shadows produced by the lamellae are at times darker than at others, the greater darkness being due to a slight rise in the lamellae. On a few occasions the fish yawned as it were, widely opening its mouth. Then the marginal flap of the disc was raised distinctly forming a fine cup surrounding the middle region of the disc giving us an idea of how it could be used when needed. Simultaneously with the formation of the cup the lamellae were also fully raised. These movements force themselves on our observation.

Eventhough on the 13th October the fish was not caught sticking to the glass side, on the next day part of the time was spent in attachment and part resting on the ground, and on subsequent days it preferred attachment. Before doing so it seems to test the surface moving forward and backwards before choosing the site. In all these matters it seems to be educated by stages in what it ought to do. Strasburgh's (1962 account of a fish preferring the same spot must have happened as the result of the judgment of the fish that the spot was the best.

At feeding time pieces of chopped fish are dropped into the tank from above and the fish darts at the food like an arrow and catches the particles before they reach the ground. While all other fish which have their mouths terminal pick up food from the bottom, the sucker fish is unable to do so because the lower jaw is greatly elongated. The fish has not been observed to turn round and pick up food from the bottom. It seems to be a suspension feeder entirely. The shark on the other hand has difficulty in eating floating food but it is able to manage by turning on its back and engulfing the food. The sucker fish does not seem to have learnt the trick because it has all along been taking food floating or living in the water from the vantage position in which it is attached.

After remaining in the tank for about 12 days it was suggested to the curator that the fish be transferred to another tank in which a huge turtle *Chelone midas* weighing about 32 lb. with a length of 24 inches, breadth 16 inches and circumference 38 inches was placed. Holmwood (1884) in the proceedings of the Zoological Society of London mentions about turtle and shark fishing, practised in East Africa with the aid of the sucker fish. About the 25th October the fish was transferred to the turtle tank.

For fear that the turtle would eat the fish it was introduced at the further end of the tank expecting that the turtle might chase it in which case it might be withdrawn. Since the fish first rested on the ground in the other tank and only later took to attaching itself to the glass, it was expected that it would have to learn to adhere to the turtle. But instead it went directly to it as though it instinctively knew what to do and adhered to its ventral surface with the head pointing towards the head of the turtle and the tail towards the tail. The position taken was not exactly median because the middle region of the turtle has a depression on it. The attachment is to one or other of the sides which are raised.

At times it released itself from the ventral side and attached itself to the dorsal about the middle line of the posterior half of its host. How far the attachment inconvenienced the host is not clear, but it was trying to release it by folding the anterior paddles below the plastron and searching for it as it were. Some times the paddles tried to dislodge the fish from its dorsal position but in every case the vigilant creature released its hold in time and reattached itself after the paddles moved away. Occasionally the turtle settled on the bottom and tried to squeeze the fish out of its position on the ventral side. The fish then brought out the food it had eaten and the host ate it up.

The tank contained rocks jutting out in the background at various angles. Attempts were also made by the turtle to rub its surfaces against the rocks to dislodge the fish from its hold. It cannot be that the shell is sensitive and informs the host. It must be that the pressure that the fish produces on the shell can be felt by the internal muscles which inform it.

Some five or six days passed during which period the fish was either attached to the host or swimming in close proximity under the shell of the turtle never far away from it. Ever since transfer to this tank the fish was never seen either to rest on the ground or to be attached to the tank. This probably was due to its awareness that it would fall a victim to its host if it did so.

On the night of the 30th October the relationship between the fish and the turtle seemed to be normal. During the day when food was dropped into the tank the fish released itself from its hold and darted at the food securing its share and returned to its perch. It was clear that the fish always preferred to stick on the under side in which it would be keeping its normal position and when it attached itself to the dorsal side it had to turn upside down and did not seem to relish it.

On the 31st October when the staff examined every tank to remove dead fish if any, the sucker fish was missing! Search was made between the jutting rocks but all to no avail. Neither the inlet nor outlet to the tank was big enough to permit of its escape. It is believed that it fell a prey to the host. Did the fish first die and then be eaten by the turtle or was there a fight between them when accidentally the host was able to seize the fish, is not known. No remnants or pieces of the sucker fish were found anywhere in the tank. It was being planned to attach a nylon string to the tail of the sucker fish and find out whether the turtle could be drawn to one side but that is now not possible.

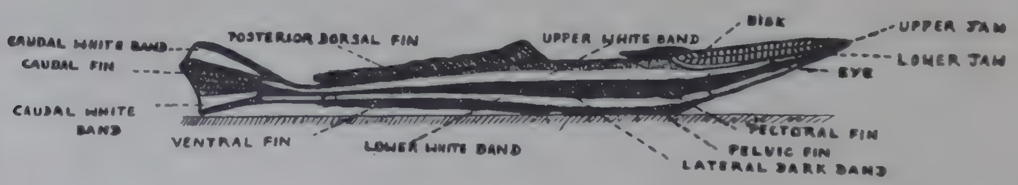
My thanks are due to the officials of the Fisheries who assisted us, to my research fellow K. Chandra Mohan who spent several hours every day observing it and to the C.S.I.R. for the grant sanctioned.

References.

Hohnwood Frederick, 1884. Proc. Zoo. Soc., London, Vol. 28, pp. 411-413.

Strasburgh. Donald W. 1962. Pacific Science April.

ECHENEIS Sp. Resting on the ground.



INSTRUCTIONS TO AUTHORS.

1. Manuscripts of papers offered for publication in the " Madras Journal of Fisheries " should be typed on one side on foolscap paper and double-spaced throughout. Pages should be consecutively numbered. Two copies of the manuscript should be submitted.

2. The title of the paper should be brief and to the point and wholly in capitals. This is followed by the author(s) name(s) with the initials preceding the surname.

3. Tables when given should not contain bulky data and should be given on separate sheets and their position in the text indicated suitably. They should be given brief headings. They should be numbered in Roman numerals and indicated in the text thus : Table I.

4. Both tables and graphs illustrating the same point will not be accepted.

5. Drawings and illustrations should be made in Indian ink on white Bristol board. Scale of magnification of *camera lucida* drawings should be properly mounted. Every drawing or photograph should be accompanied by the relevant legends. Maps should have the latitude and longitude clearly marked. Figures should be numbered in Arabic numerals and indicated in the text thus : Fig. 1.

6. Names of all simple chemical compounds rather than their formulae should be used in the text.

7. All measurements should be given in the metric system only.

8. Citation of literature should have author, year, title, name of journal, volume number and inclusive pages.

Abbreviations of the names of journals should be according to " *World List of Scientific Publications* " (3rd edition 1952) or to recognised form only.

Examples : Atkins, W.R.G. 1923. The phosphate content of fresh and salt waters in its relationship to algal plankton. J. Mar. Biol. Ass. V. 13 ; 119–150 Harvey, H.W. 1931. *Biological Chemistry and Physics of Sea Water.* Cambridge Univ. Press.

In the text the reference should be cited thus : Ralph and Hurley (1952), with the author's surname followed by the year of publication in parenthesis.

9. All manuscripts should be sent to :

The Director of Fisheries,
Editor, "Madras Journal of Fisheries",
Administrative Office Buildings,
MADRAS–6.

PRINTED BY THE DIRECTOR OF STATIONERY AND PRINTING, MADRAS, ON BEHALF OF THE GOVERNMENT OF TAMIL NADU—1969.